The Effects of Mindfulness Meditation on Spectral Measures of EEG Activity

Alice Bosworth

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Statement of Sources

I report that this report is my own original work and that contributions of others have been duly acknowledged

________________________ Date:_____________________

Alice Bosworth

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Abstract

Mindfulness meditation is associated with improvements in emotional regulation and attention, however the neural mechanisms underlying these relationships are not well understood. Meta-analyses of electrophysiological changes during meditation, indicate that meditative states are most consistently associated with increased alpha and theta power, and preliminary evidence suggests that mindfulness meditation practice may reduce frontal theta/beta ratio, a potential electrophysiological marker of attentional control. However, studies in this area are limited by methodological issues, such as the use of cross-sectional designs and lack of active control groups. This study aimed to address limitations of previous research by conducting a randomised control trial which examines whether electrophysiological changes occur after one week of mindfulness meditation training with neurofeedback. Participants with low meditation experience (*N*=33) were randomised into a one-week intervention (at least 20 minutes for seven days) of either mindfulness meditation training with neurofeedback or relaxation training with biofeedback. Measures of mindfulness, mood, and emotional regulation were taken at pre training and post training sessions. Results indicated that there was no change in theta power, alpha power or theta/beta ratio, from pre training to post training in the focused breathing condition for both groups, and measures of mindfulness, suggesting that the dose of meditation the experimental group received was not sufficient to lead to changes in electrophysiological measures. Future research could extend the duration of the mindfulness meditation intervention to address this possibility.

There has been growing scientific interest in mindfulness meditation and its effects on wellbeing and cognitive processes. Mindfulness meditation is a type of meditative technique from the Buddhist tradition that aims to develop a practitioner's level of mindfulness. Mindfulness is the "awareness that emerges through paying attention on purpose, in the present moment, and non-judgementally to the unfolding of experience moment by moment" (Kabat-Zinn, 2003, p. 145). Mindfulness meditation involves focusing attention in the present moment on an intended object, such as the breath or bodily sensations, while nonjudgmentally acknowledging passing thoughts and emotions (Ivanovski & Malhi, 2007). Practices include those from the Buddhist tradition, such as Zen and Vipassana, and more recent mindfulness-based psychological interventions, such as Mindfulness Based Stress Reduction (MBSR) (Tang, Holzel, & Posner, 2015)

Mindfulness meditation is associated with a number of benefits, including improvements in emotional regulation (Teper, Segal, & Inzlicht, 2013) and attention (Jha, Krompinger, & Baime, 2007), and is efficacious when incorporated into a number of mindfulness based interventions for psychological conditions (Bowen et al., 2006; Hofmann, Sawyer, Witt, & Oh, 2010). However, the neural mechanisms underlying these relationships are still not well understood (Lagopoulos et al., 2009; Malinowski, 2013; Moore & Malinowski, 2009). It is acknowledged that more methodological rigorous studies are needed to improve our understanding of the neuropsychological processes responsible for these changes to enable the development and refinement of mindfulness based interventions (Malinowski, 2013; Moore, Gruber, Derose, & Malinowski, 2012).

State and trait neurophysiological changes occurring from meditation provide insight into these processes and can be examined using electroencephalography (EEG)

(Ivanovski & Malhi, 2007). EEG is a technique which measures cortical activity by recording electrical signals from the scalp (Reilly & Lee, 2010). These electrical signals can be analysed by their amplitude, which indicates the level of synchronised activity in the underlying tissue, and their frequency, which is the number of oscillatory cycles per second, commonly divided into the following spectral bands; alpha (8-13 Hz), delta (1-4 Hz), theta (4-7 Hz), gamma (36-44 Hz), and beta (13-30 Hz) (Lomas, Ivtzan, & Fu, 2015).

Although the effects of meditation on EEG measures are not clearly established, meta-analyses indicate that meditative states are most consistently associated with increases in alpha and theta band power compared to a resting state, indicating a state of "relaxed alertness", with no consistent patterns observed for the other bands (Cahn & Polich, 2006; Lomas et al., 2015). Alpha band power is associated with relaxation and internally directed attention (Shaw, 1996), and theta band power is observed in tasks which require sustained concentration (Smith, McEvoy, & Gevins, 1999).

However, studies investigating the effects of meditation on EEG measures are generally limited by methodological issues, such as the use of cross-sectional designs, the lack of active control groups in longitudinal designs, and the use of study designs which confuse the state and trait effects of meditation. Therefore, there is a need to investigate the effects of mindfulness meditation on EEG measures using a randomised controlled longitudinal study design with participants with low meditation experience and an active control group to address the limitations of previous research.

Alpha Band Power

Increases in alpha band power during meditation have been observed in experienced meditators when they are compared to matched controls (Huang & Lo, 2009), and in experienced meditators during meditation compared to a resting state (Aftanas & Golocheikine, 2002; Lagopoulos et al., 2009). It is also observed amongst novice meditators during their first session of Zen meditation (Takahashi et al., 2005; Yu et al., 2011). Longitudinal studies have also found an increase in alpha band power during mindfulness meditation compared to a resting state after six weeks of training (Ahani et al., 2014), and after 16 weeks of training (Dunn, Hartigan, & Mikulas, 1999). However, no difference in alpha band power was observed in long term Vipassana meditators during meditation compared to a control resting state (Cahn, Delorme, & Polich, 2010). As increases in alpha power are observed during meditation regardless of depth of meditation, it has been suggested that alpha power increases observed in experienced meditators could reflect ease in performing the task rather than a specific meditative state, as studies which have controlled for relaxation or counterbalanced relaxation conditions have not found increased alpha during meditation (Cahn & Polich, 2006; DeLosAngeles et al., 2016).

The role of alpha in meditation still remains unclear (Lomas et al., 2015). Previously alpha synchronisation was thought to reflect "cognitive idling" because it is observed when sensory information is not being processed, whilst alpha desynchronises when engaged in a task (Pfurtscheller, Stancak Jr, & Neuper, 1996). However, recent evidence suggests that enhanced alpha reflects internally directed attention and indexes the inhibition of task-irrelevant sensory information required to perform internally directed attentional tasks (Cooper, Croft, Dominey, Burgess, & Gruzelier, 2003; Jensen

& Mazaheri, 2010; Shaw, 1996). Increased alpha has been observed in tasks that require internally directed attention, such as mental arithmetic, mental rotation of objects, and imagination (Cooper et al., 2003; Klinger, Gregoire, & Barta, 1973; Ray & Cole, 1985a, 1985b). As mindfulness meditation involves training attentional networks, it can be inferred that the increase in alpha power is an indicator of enhanced processing of internally generated stimuli (Lomas et al., 2015).

Theta Band Power

An increase in theta band power in the frontal midline area during meditation has been observed in experienced meditators during meditation compared to a resting condition (Aftanas & Golocheikine, 2001; Aftanas & Golosheikin, 2003; Baijal & Srinivasan, 2010; Banquet, 1973; Cahn et al., 2010; DeLosAngeles et al., 2016; Lagopoulos et al., 2009; Murata et al., 1994), and in meditation naïve participants practising Zen meditation for the first time (Takahashi et al., 2005). Longitudinal studies have also found an increase in theta power during mindfulness meditation after six weeks of practice (Ahani et al., 2014), and after five days of Integrative Mind Body practice (IMBT) (Tang et al., 2009). However, one study found a decrease in theta power during mindfulness meditation compared to a resting state after 16 weeks of training (Dunn et al., 1999), and another in novice meditators during their first session of Zen meditation (Yu et al., 2011). These inconsistent findings may be due to the limited amount of meditation practice experience of the participants (Yu et al., 2011), as research has found a positive correlation between theta activity and amount of meditation experience (Fell, Axmacher, & Haupt, 2010; Murata et al., 1994).

Frontal midline theta activity is also observed during cognitive tasks which require sustained concentration (Inanaga, 1998; Smith et al., 1999), such as mental arithmetic (Sasaki, Tsujimoto, Nishikawa, Nishitani, & Ishihara, 1996). It is theorised that frontal midline theta is the mechanism which signals the need for cognitive control to other brain regions (Cavanagh & Frank, 2014). The Anterior Cingulate Cortex (ACC) and Prefrontal Cortex (PFC) are estimated to be the neural sources of frontal midline theta (Asada, Fukuda, Tsunoda, Yamaguchi, & Tonoike, 1999; Ishii et al., 1999). The ACC is involved in tasks that require executive function (Hanslmayr et al., 2008) and an increase in frontal midline theta is observed during conflict in the Stroop task, a task which requires executive function, with increased phase coupling between ACC and PFC (Vogt, Finch, & Olson, 1992). The ACC is involved in conflict monitoring and signals the need for cognitive control to the PFC which implements the necessary cognitive control processes and behavioural adjustments (Botvinick, Cohen, & Carter, 2004; Hanslmayr et al., 2008; Kerns et al., 2004; Van Veen & Carter, 2002). The ACC and PFC are activated during mindfulness meditation in experienced meditators (Hölzel et al., 2007). It is thought that during meditation, external stimuli unrelated to task demands, such as thoughts and memories, represent conflict to the current task demands and the ACC will monitor this and signal to the PFC the need for control processes to refocus attention (Chiesa & Serretti, 2010).

Meditation and Executive Control

The development and improvement of attention skills are considered key processes in mindfulness meditation training and are included in most conceptualisations of mindfulness meditation (Malinowski, 2013). Evidence suggests that meditation improves sustained attention and the ability to control limited attentional resources (Slagter et al., 2007). Several attentional networks will interact to maintain focused attention during meditation, as sustaining attention on the breath involves monitoring and regulating the attentional focus and employing attentional control processes when they are required (Malinowski, 2013). Three central executive processes are engaged in attentional control; updating, which involves monitoring and updating information, shifting, which involves shifting between tasks or mental sets, and inhibition, which involves deliberately inhibiting dominant or proponent responses which are not task relevant (Miyake & Friedman, 2012; Miyake et al., 2000).

Cross-sectional studies comparing experienced meditators with matched meditation-naive controls have found performance in attentional control tasks is positively correlated with daily time spent meditating (Chan & Woollacott, 2007; Malinowski, 2013; Moore & Malinowski, 2009) and improvements in attentional control in longitudinal studies have been observed after three 20-minutes sessions and one 20-minute session of meditation (Wenk-Sormaz, 2005).

Theta/Beta Ratio and Attentional Control

Frontal theta/beta ratio (TBR), the ratio of theta band power divided by beta band power, has been identified as a potential electrophysiological marker of executive control, especially attentional control, in healthy adults (Angelidis, van der Does, Schakel, & Putman, 2016). Resting TBR is elevated in those with ADHD, a disorder characterised by reduced attentional control (Arns, Conners, & Kraemer, 2013), and stimulant medications used in the treatment of ADHD reduce atypical TBR closer to normal levels and are associated behavioural improvements (Chabot, Orgill, Crawford, Harris, & Serfontein, 1999; Clarke, Barry, Bond, McCarthy, & Selikowitz, 2002). Several cross-sectional studies have found a negative correlation between TBR and self-reported trait attentional control in healthy populations (Angelidis et al., 2016; Putman, van Peer, Maimari, & van der Werff, 2010; Putman, Verkuil, Arias-Garcia, Pantazi, & van Schie, 2014).

Theta/Beta Ratio and Meditation

As mindfulness meditation practice is associated with improvements in attentional control, and TBR has been identified as a promising electrophysiological marker of attentional control, it is theorised that mindfulness meditation practice should lead to a reduction in TBR. However, to our knowledge, no studies have looked at the effect of mindfulness meditation on TBR in a randomised controlled longitudinal study with a healthy population.

One longitudinal study investigated changes in TBR in youth diagnosed with ADHD after a mindfulness-based intervention. It was found that after a 20-week mindfulness based martial arts program, there was a decrease in TBR during attentional tasks which was not observed at rest (Sibalis et al., 2019). In contrast, a cross-sectional study of experienced Zen meditators and meditation-naive participants found a correlation between frequency of meditation practice and an increase, rather than a decrease, in induced TBR during meditation (Pasquini et al., 2015).

TBR has also been associated with mind wandering. During a breath counting task, TBR was found to be significantly higher during mind wandering episodes compared to on task periods (van Son et al., 2019a), which the authors suggest is consistent with the view that mind wandering is a state of reduced attentional control during task performance (McVay & Kane, 2009; van Son et al., 2019a).

Meditation and Technology

Whilst mindfulness meditation is associated with improvements in attention and emotional wellbeing, its effectiveness is contingent on amount and quality of practice (Crivelli, Fronda, Venturella, & Balconi, 2018). However, gradual decreases in motivation and commitment are often observed with traditional meditation programs (Balconi, Fronda, & Crivelli, 2018). It has been suggested that the use of devices that provide real-time neurofeedback on a user's brain states and track progress over time may make meditation more accessible to beginners and increase motivation (Balconi et al., 2018; Crivelli et al., 2018).

Advantages of using technology-based devices over traditional programs include greater accessibility for those who cannot attend organised group programs and more flexibility in creating a training program that suits the needs of the individual (Bhayee et al., 2016). Furthermore, the integration of meditation practice with neurofeedback may enhance attention regulation abilities as it increases awareness of current brain states, allowing an individual to re-orient their attention when alerted that the mind has wandered (Crivelli et al., 2018).

Studies have found improvements in attention and wellbeing following the use of neurofeedback-assisted technology-supported mindfulness training interventions. Bhayee et al. (2016) found that six weeks of using this technology lead to improvements in attention, processing speed, and wellbeing. Four weeks of training with the same neurofeedback assisted technology device improved attentional control and increased the alpha/beta ratio at rest in comparison to a control group with no neurofeedback (Crivelli et al., 2018). However, properly controlled investigations on the efficacy of interventions using these devices remain limited (Crivelli et al., 2018) and these studies did not include a control group that also had devices, therefore some of the observed effects could be related to expectancy .

Limitations of Previous Research

The generalisability of findings from studies investigating the effects of meditation on EEG measures are limited by methodological issues (Chiesa & Serretti, 2010; Ivanovski & Malhi, 2007; Moore et al., 2012). Studies in this area often use a cross-sectional study design, comparing experienced meditators to matched controls, which makes it difficult to establish whether the observed differences between groups are due to meditation training or individual differences which may draw someone to practice meditation and to continue to practice for a significant period of time (Cahn & Polich, 2006; Moore et al., 2012).

Other studies which compare experienced meditators at rest and during meditation may confuse state and trait effects (Baijal & Srinivasan, 2010; Cahn & Polich, 2006), as meditation causes trait changes at rest and experienced meditators find it difficult not to start meditating when they are asked to sit and rest (Cahn et al., 2010; Cahn & Polich, 2006). There is also a large degree of variation in cross sectional studies in who is classified as an experienced or novice meditator (Lomas et al., 2015; Van Dam et al., 2018), and studies often equate meditation proficiency with the duration of time spent meditating over lifetime, however, there may be differences in meditation proficiency between those that have meditated for the same amount of time (Kakumanu et al., 2018). Another issue is that some studies compare meditators and controls when they are assigned to different conditions or assigned to different length conditions (Pasquini et al., 2015).

The majority of mindfulness meditation research has examined mindfulness-based interventions which incorporate other elements beside mindfulness meditation, such as Mindfulness Based Stress Reduction (MBSR) (Kabat-Zinn, 1990), an eight-week program involving mindfulness meditation, group meetings, yoga, and psychoeducation about stress and emotions (Bhayee et al., 2016; Moore & Malinowski, 2009), making it difficult to establish whether mindfulness is the causal mechanism behind the changes observed. A meta-analysis of mindfulness meditation research found that studies using MBSR had the largest increase in psychological wellbeing, whereas studies using only mindfulness meditation showed the largest increase in mindfulness measures, suggesting that some of the observed improvements in wellbeing associated with MBSR may be attributed to other factors of the program aside from mindfulness, such as psychoeducation or expectancy (Eberth & Sedlmeier, 2012).

Longitudinal studies in the area also have some methodological limitations, such as not having a control group (eg. Dunn et al. (1999) or only using a waitlist control group (eg. Chambers, Lo, and Allen (2007). It is not possible to blind participants to the nature of the intervention in meditation studies as they will know they are meditating (Davidson & Kaszniak, 2015; Slagter, Davidson, & Lutz, 2011). Therefore, it is important to consider the potential effects expectancy, demand characteristics, and motivation, may have on outcomes and attempt to control for these by including a comparison group who engage in training which matches the training the experimental condition completes, except for the specific factor under investigation (Davidson & Kaszniak, 2015; Slagter et al., 2011).

Current Aims and Hypotheses

Whilst improvements in attention and wellbeing are associated with mindfulness meditation practice, the neural mechanisms underlying these relationships are still not well understood (Lagopoulos et al., 2009; Malinowski, 2013; Moore & Malinowski, 2009). Recently, it has been acknowledged that more methodologically rigorous studies are needed to improve our understanding of the psychological and neuropsychological processes responsible for these changes (Ivanovski & Malhi, 2007; Lutz, Slagter, Dunne, & Davidson, 2008; Malinowski, 2013; Moore et al., 2012; Tang et al., 2015).

The current study aims to examine whether electrophysiological changes occur during focused breathing after a week of mindfulness meditation training with neurofeedback and to address the methodological issues present in other studies by conducting a randomised controlled longitudinal study of participants with low meditation experience.

In comparison to other longitudinal studies which have not included a control group or have used a wait list control group, this study will include an active control group who complete relaxation training using a device designed for stress management which measures changes in skin conductivity and gives the user feedback on their physiological arousal. Other studies which have examined neurofeedback technology assisted meditation devices have not included a control group who also had a biofeedback device, therefore the inclusion of a control group with a device may control for expectancy effects related to having such a device.

As research involving meditation interventions often lack reliable measures of meditation ability or adherence to practice (Ahani et al., 2014), the use of a neurofeedback technology assisted technology device in this study may help to address this issue as the app records information on total meditation time and meditation proficiency. Furthermore, no longitudinal randomised controlled trial with a healthy population has examined the effect of mindfulness meditation on TBR, a promising electrophysiological marker of attentional control.

In line with previous research, it is hypothesised that alpha and frontal midline theta band power will increase from pre-training to post-training during focused breathing for the mindfulness meditation with neurofeedback condition in comparison to the relaxation with biofeedback condition. Based on previous research that meditation practice improves attentional control, it is hypothesised that there will be a decrease in TBR, indicating improved attentional control, for the mindfulness meditation with neurofeedback condition in comparison to the relaxation with biofeedback condition, from pre-training to post-training during the focused breathing condition.

As research indicates that alpha and theta power increase when eyes are closed (Barry, Clarke, Johnstone, Magee, & Rushby, 2007), and increase further during meditation, it is hypothesised that alpha and theta power will be lowest in the eyes open condition, and higher in the eyes closed condition, followed by the focused breathing condition. It is hypothesised that TBR will decrease in the focused breathing condition, as this requires more attentional control, compared to the eyes open and eyes closed conditions.

For the outcome measures, it is hypothesised that there will be increases in the Mindful Attention Awareness Scale (MAAS) and the Cognitive and Affective Mindfulness Scale-Revised (CAMS-R), indicating increased mindfulness, along with a decrease in the State Difficulties in Emotional Regulation Scale (S-DERS), indicating improved emotional regulation, for the mindfulness meditation with neurofeedback condition in comparison to the relaxation with biofeedback condition from the pre-training session to the post training session.

Method

Participants

A priori power calculations (G-Power 3.1.9.2) indicated that a sample size of 40 participants would be adequate to detect a moderate effect size (f=0.25) with a power of 0.8 (a=.05). Thirty-three participants (22 female, aged 19-30, M=22.42, SD=2.89) were recruited for the current study. Two participants completed Session 1 but did not complete Session 2. Due to technical difficulties with the EEG recording equipment, EEG was not recorded for two participants in Session 1 and one participant in Session 2. The final sample consisted of 33 participants (18 control) for the outcome measurements, and 32 (18 control) for the EEG recording.

Participants were recruited by flyers posted on noticeboards at the University of Tasmania campus, social media posts, and the online psychology research participation portal (SONA). Participants were reimbursed a $60 gift voucher or four hours of research participation credit and a $20 gift voucher. Interested participants were directed to an online eligibility survey, and those eligible to participate were contacted.

Participation was limited to those with low meditation and relaxation experience (none in the last year and less than five hours in their lifetime), as measured by a customised meditation/relaxation experience questionnaire. Eligibility was also limited to those who had normal or corrected to normal vision and hearing, spoke English as a first language, and were aged 18-35 years. Exclusion criteria included recent history of illicit drug use, current use of psychiatric medications, current sleep disorders, history of psychiatric or neurological disorders, severe head injury, seizure, giddiness or loss of consciousness (> 2 minutes), heart conditions or any other serious physical condition, pregnancy or high likelihood of pregnancy, high levels of psychological distress (as indicated by scores >30 on the Kessler Psychological Distress Scale (K10; Kessler et al., 2002), or risk of alcohol dependence (as indicated by scores >16 on the Alcohol Use and Disorders Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001).

Materials and Apparatus

Screening measures. Participants completed an online screening questionnaire prior to participating covering demographic information, medical history, and drug use history (Appendix A). The screening questionnaire included a Meditation/Relaxation Experience Questionnaire, to screen for meditation and relaxation experience, the Kessler Psychological Distress Scale (K10; Kessler et al., 2002), to screen for high levels of psychological distress, and the Alcohol Use and Disorders Identification Test (AUDIT; Babor et al., 2001), to screen for problematic alcohol use.

The Meditation/Relaxation Questionnaire is a customised self-report questionnaire which assessed participants' previous meditation and relaxation experience, including forms of meditation or relaxation experience, amount of time spent meditating or relaxing per week in the past year, and hours spent practising meditation or relaxation in lifetime.

The AUDIT is a ten-item self-report measure used to identify problematic alcohol use (Babor et al., 2001). Items are scored on a range of 3-point and 5-point scales. Scores range from 0-40, with scores of 16 or above indicating problematic alcohol use (Babor et al., 2001). The AUDIT has high internal consistency, reliability, criterion validity and construct validity (de Meneses-Gaya, Zuardi, Loureiro, & Crippa, 2009; Reinert & Allen, 2007).

The K10 is a ten-item scale which measures symptoms of non-specific psychological distress experienced in the past 30 days (Kessler et al., 2002). Items are scored on a 5-point scale from 1 (‘none of the time’) to 5 (‘all of the time’). Scores range from 10-50, with scores of 30 or above indicating a high level of psychological distress.

An experimental session questionnaire (Appendix B) was used to assess whether participants had complied with the participation requirements and were eligible to participate in the experimental session that day. Questions covered recent alcohol consumption and illicit drug, caffeine, tobacco, and medication use.

Control Measures. As a control, groups were compared on trait anxiety, measured by the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) (Appendix C), trait mindfulness, measured by the Five Facet Mindfulness Questionnaire (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) (Appendix D), on verbal intelligence, measured by the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) (Appendix E), and subjective level of present sleepiness at each session, measured by the Karolinska Sleepiness Scale (KSS) (Appendix F).

The STAI-T is 20-item self-report which measures trait anxiety (Spielberger et al., 1983). Respondents are asked how they generally feel on a 4-point scale from 1 (‘almost never’) to 4 (‘almost always’). The STAI has high internal consistency and good test-retest reliability (Barnes, Harp, & Jung, 2016).

The FFMQ-15 is a fifteen-item short form of the 39-item FFMQ which measures mindfulness in daily life. Items measure the five facets of mindfulness; observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience (Baer et al., 2006). Scores on the FFMQ are associated with meditation experience and psychological and wellbeing symptoms in meditators and non-meditators (Baer et al., 2008).

The WTAR is a measure of verbal intelligence which is highly correlated with full scale IQ scores (Green et al., 2008; Wechsler, 2001). It consists of fifty words with irregular pronunciation which a participant is asked to read aloud. A point is given for each word that is pronounced correctly, with higher scores indicating higher verbal intelligence.

Secondary outcome measures. Secondary outcome measures were taken at Session 1 and Session 2 to compare changes in mood, measured by the Profile of Mood States-Short Form (POMS-SF; Shacham, 1983) (Appendix G), mindfulness, measured by the Cognitive and Affective Mindfulness Scale (CAMS-R; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2006) (Appendix H) and the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003) (Appendix I), and state emotional dysregulation, measured by the State Difficulties in Emotional Regulation Scale (S-DERS; Lavender, Tull, DiLillo, Messman-Moore, & Gratz, 2017) (Appendix J).

The POMS-SF is a measure of transient feelings and moods (Shacham, 1983). The measure has six subscales; Fatigue-Inertia, Vigour-Activity, Tension-Anxiety, Depression-Dejection, Anger-Hostility, and Confusion-Bewilderment. A total mood disturbance score can be calculated by combining the scores and subtracting the vigour scale. The POMS-SF has good convergent validity with the long version (Curran, Andrykowski, & Studts, 1995).

The CAMS-R is a 12-item self-report measure designed to capture the construct of mindfulness written in language that is understood by non-meditators (Feldman et al., 2006). The measures has good internal consistency, and convergent and discriminant validity (Feldman et al., 2006).

The MAAS is a 15-item self-report measure designed to measure dispositional mindfulness (Brown & Ryan, 2003). The measure has good convergent validity with others measures of psychological wellbeing and is able to discriminate between experienced meditators and non-meditators (Brown & Ryan, 2003)

The S-DERS is a 21-item self-report measure designed to assess state-based emotion dysregulation. It has four subscales; non-acceptance, modulate, awareness, and clarity. It has good internal consistency and construct validity (Lavender et al., 2017).

Visual Analogue Scales (VAS) (Appendix K) were used to determine subjective experiences before and after the focused breathing task and were adapted from a daily experience sampling questionnaire used in Bhayee et al. (2016). Ratings of agreement to ten statements of feelings at the present moment were provided along a 10cm continuum, ranging from ‘strongly agree’ to ‘strongly disagree’. Lower scores indicated higher agreement with each item.

Focused breathing task. The focused breathing task was adapted from an “adapted meditation exercise” used in Pasquini et al. (2015). It is designed to enable meditation-naive participants to obtain a meditative state. It consists of three five minutes blocks of eyes open rest, eyes closed rest, and focused breathing. The instructions for the Eyes open condition are: ‘You are asked to sit comfortably with your eyes open for five minutes. Rest and let your mind wander freely until you hear the sound of a tone. When you hear the tone, you can have a break.' For the eyes closed condition the instructions are the same but participants are asked to keep their eyes closed. For the focused breathing condition the instructions are: 'You are asked to sit comfortably and focus on your breath for five minutes. Close your eyes and focus your attention on the sensation of your breath entering and leaving the body, such as at the sensation at the nostrils or the rising and falling sensation of the abdomen. There is no need to think about or try to control your breath, simply focus on the sensation of it. If you notice that your awareness is no longer on the breath, gently bring your attention back to the sensations of the breath.'

The Muse. The Muse™ headband (InteraXon Inc., Ontario, Canada) is a non-invasive EEG recording system which interacts with a dedicated app to provide neurofeedback to the user. The Muse headset extends across the forehead and fits behind the ears. It has four dry sensors, two located on the forehead, and two located at the mastoids (Bhayee et al., 2016). The app delivers audio instructions on mindfulness meditation and provides audio feedback in the form of natural sounds when brain signals are focused or distracted. All sessions and progress are recorded within the app.

The Pip. The Pip (Galvanic Ltd, Ireland) is a wireless biofeedback device which is held between the thumb and forefinger which measures electrodermal activity (EDA). Information about electrodermal activity is transmitted via Bluetooth to an associated mobile phone app 'Loom.' The goal during a session in the app is to change an image of a landscape from frozen through to summery by decreasing electrodermal activity. All sessions and progress are recorded within the app.

Electroencephalographic (EEG) recording. Continuous EEG activity was recorded at 1000Hz through a NeuroSCAN 4.5 system and a 32-Channel Quik-cap. Ag/AgCI sintered electrodes were placed according to the 10-20 International system of electrode placement (Jasper, 1958). Electrode impendence was kept less than 10kΩ. Horizontal and vertical electrooculographic activity was gathered from the outer canthi of both eyes and from above and below the left eye in line with the pupil. The signals were recorded with a band pass filter (0.05-30Hz). The breaks between the eyes open, eyes closed, and focused breathing tasks were blocked out. Data was band pass filtered (0.1-40Hz, 24db/octave) with a zero-phase shift with a FIR. Ocular artefact reduction was conducted, using regression computation and artefact averaging, to reduce the influence of eye blinks on the electrode channels. Data was visually inspected and sections containing residual muscle artefacts or ocular artefacts were manually rejected. Data was then segmented into eyes open, eyes closed, and focused breathing segments. Four second epochs were extracted and epochs with artifacts ±200µv were rejected (van Son et al., 2019a). Data was then subjected to Fast Fourier Transformation (Hamming window length 10%, resolution: 0.2Hz) to calculate power for the alpha (8-13Hz), beta (13-30Hz), and theta (4-7Hz) bands (Angelidis, Hagenaars, van Son, van der Does, & Putman, 2018).

For the analysis of alpha power, average power density of the alpha band for the midline electrodes (Fz, Cz, and Pz) was extracted (Crivelli et al., 2018). For the analysis of frontal midline theta, average power density of the theta band was extracted from the frontal midline area (Fz) To calculate the frontal theta/beta ratio, the power densities of theta and beta were averaged at the three frontal sites (Fz, F3, F4), then the ratio of theta was divided by beta and log transformed (Angelidis et al., 2018).

Procedure

The current study was approved by the University of Tasmania Human Research Ethics Committee (Appendix L). Eligible participants completed two two-hour experimental sessions booked seven days apart. Randomisation to condition was conducted using an online randomisation generator in blocks of four. Participants were asked to refrain from taking illicit drugs, consuming alcohol (24 hours) and caffeine (2 hours) prior to each experimental session. Upon arrival at the pre-training session, participants were given an information sheet (Appendix M) before providing written consent (Appendix M). Participants completed an experimental session questionnaire to confirm eligibility to participate that day, followed by the POMS-SF, S-DERS, CAMS-R, MAAS, KSS, and the WTAR.

EEG was set up and the participants were seated in front of a computer screen in a dimly lit sound-attenuated room. Participants first completed an Attentional Network Task and an Emotional Stroop Task which did not form part of this thesis.

Participants completed the VAS and then were given verbal instructions about the task and told instructions would also appear on the computer screen. EEG activity was recorded while participants engaged in three five-minute conditions; eyes open rest, eyes closed rest, and focused breathing. After each five-minute condition there was the sound of a tone, and written instructions appeared on the computer screen informing the participant that they could have a rest and a stretch before pressing a key when they were ready to continue to the next task. Participants then completed the VAS, and EEG equipment was removed.

Participants received instructions about their allocated training condition. The researcher assisted the participant to download the Muse App or the Pip app instructed them how to use the device. Participants were given written instructions regarding the device and app setup, troubleshooting, and safety information and provided a schedule for each session to be completed over the week (Appendix N). Participants then completed a Training Outcome Questionnaire (Appendix O).

At the post-training experimental session, the same procedures were followed, however participants only completed the Experimental session questionnaire, POMS-SF, CAMS-R, MAAS, KSS, and S-DERS. At the end of the experimental session participants completed a survey regarding their use of the Muse or Pip device over the seven-day period and entered data from the app for total days, sessions, and minutes spent meditating or relaxing. Participants were then debriefed and reimbursed.

Design and Analysis

Two participants did not return for Session 2 due to personal reasons. Due to equipment faults, two participants did not provide electrophysiological data for the first session and one participant did not provide electrophysiological data for the second session. This resulted in thirty-three participants providing data for the outcome measures, and thirty-two participants providing electrophysiological data.

To examine whether there were any differences between the control group and the experimental group in demographics and control measures, one-way ANOVAs were used to analyse age, alcohol usage (AUDIT), psychological distress (K10), trait mindfulness (FFMQ), trait anxiety (STAI-T), and estimated verbal intelligence (WTAR). One-way ANOVAs were also used to compare groups on expectancy measures and training adherence. A chi-square analysis was conducted to examine any differences in biological sex between the groups. To examine whether there were any differences in sleepiness between the groups and sessions, subjective level of sleepiness (KSS) was analysed using a 2 (Group: mindfulness, relaxation) x 2 (Time: pre, post) repeated measures ANOVA.

The secondary outcome measures, the POMS, S-DERS, CAMS-R, and MAAS, were analysed using a 2 (Group: mindfulness, relaxation) x 2 (Time: pre, post) repeated measures analysis. Assumptions for a repeated measures analysis were checked. Two participants were identified as being outliers on the POMS but were kept in the analysis as a preliminary analysis revealed that their scores did not significantly influence the results.

For the electrophysiological data, a Mixed Linear Models analysis was conducted to account for incomplete data. The model hierarchy for the analyses included two levels where the repeated factors (Level 1) were nested within the subjects variable (Level 2). A model comparison using Maximum Likelihood ratio was conducted to compare the fit of models with a compound-symmetry covariance structure or an unstructured covariance structure. Assumptions for a mixed linear model analysis were checked. Preliminary analyses conducted with a log-transformation revealed that the log-transformation did not significantly influence the results, therefore raw data was reported. The dependant variables were alpha power, frontal midline theta power, and theta/beta ratio. The dependant variables were analysed by 3 separate 2 (Group: mindfulness, relaxation) x 2 (Time: pre, post) x 3 (Condition: eyes open, eyes closed, focused breathing) mixed models analyses.

For the Visual Analogue Scales (VAS), the dependant variables were Distracted, Calm, Stressed, Accepting, Aware, Present-focused, Disinterested, Fatigued, and

Attentive, and these were each analysed with 2 (Group: mindfulness, relaxation) x 2 (Time: Session 1, Session 2) x 2 (Prepost: Pre, Post) repeated measures ANOVAs.

Partial eta squared (η_p^2) is included as effect size for the one-way ANOVAs and repeated measures analyses and can be interpreted as the amount of variance in the dependant variable, which is explained by the independent variable, with 0.01= small, 0.06= medium, and 0.14= large. Significant main effects and interactions (>.05) were followed by Bonferroni pair-wise comparisons to control for the Type I error rate. Effects sizes for one-way comparisons were measured using Hedge's g which is appropriate for small sample sizes (Turner & Bernard, 2006), and this was interpreted according to Cohen's guidelines (0.2=small, 0.5=medium, 0.8=large) (Cohen, 1992).

Results

Demographics and Control Measures

Descriptive statistics for demographic and control variables are presented in Table 1. There was no significant differences between the groups in age, $F(1,32)=.05$, $p=.834$, $g=0.06$, alcohol usage (AUDIT), $F(1, 32)=0.48$, $p=.495$, $g=0.23$, psychological distress (K10), $F(1, 31)=0.41$, $p=.529$, $g=0.22$, trait mindfulness (FFMQ), $F(1,31)=1.81$, $p=.188$, $g=0.46$, trait anxiety (STAI-T), $F(1, 32)=0.23$, $p=.637$, $g=0.16$, and estimated verbal ability (WTAR raw scores), $F(1, 31)=0.09$, $p=.761$, $g=0.07$. A chi-square analysis revealed that there was no significant difference between the proportion of males and females in each group, $\chi 2$ $(1)=0.24$, $p=.622$. There was no significant difference in level of sleepiness (KSS) at the experimental sessions between the relaxation group and mindfulness group, $F(1, 29)=1.01$, $p=.323$, $\eta_p^2=.034$, and between Session 1 and Session

2, *F*(1,29)=0.00, *p*=.987, g<.001, and the Time x Group interaction was non-significant, *F*(1,29)= .261, *p*=.614, η_p^2=.01.

Table 1.

Descriptive Statistics for Control Measures: Age, AUDIT, K10, FFMQ, STAI-T, WTAR, and KSS for the Relaxation and Mindfulness Groups.

Variable	Relaxation		Mindfulness	
	M(SD)	95% CI [*LL*,*UL*]	*M(SD)*	95% CI [*LL*, *UL*]
Age	22.5 (2.5)	[21.2, 23.8]	22.3 (3.3)	[20.5, 24.1]
AUDIT	3.6 (2.6)	[2.3, 4.9]	4.31 (2.9)	[2.7, 5.9]
K10	14.2 (4.2)	[12.1, 16.4]	15.2 (4.4)	[12.7, 17.6]
FFMQ	47.6 (8.2)	[43.4, 51.9]	51.0 (5.8)	[47.9, 54.1]
STAI-T	38.3 (7.1)	[34.2, 42.4]	36.9 (8.4)	[32.5, 41.4]
WTAR	41.9 (5.3)	[39.22, 44.6]	41.43 (3.9)	[39.3, 43.6]
KSS				
Session 1	3.9 (1.4)	[3.2, 4.7]	3.4 (1.1)	[2.8, 4.0]
Session 2	3.81 (1.4)	[3.1, 4.6]	3.5 (1.3)	[2.8, 4.2]

Note. CI= confidence interval; *LL*= lower limit; *UL*= upper limit.

Expectancy Measures and Training Adherence. Descriptive statistics for expectancy measures and training adherence are displayed in Table 2. An analysis of the expectancy measures revealed that there was no significant difference in expectancy ratings between the groups that the intervention would improve attention, $F(1,29)=3.67$, $p=.066$, $g=0.68$, ability to complete the computer tasks, $F(1,29)=.17$, $p=.679$, $g=0.14$, or emotional wellbeing, $F(1,29)=1.78$, $p=.193$, $g=0.48$.

For training adherence, there was no significant difference between the groups in the number of days participants completed training sessions, $F(1,29)=3.16$, $p=.086$, $g=0.65$. For total number of sessions, the relaxation group completed significantly more training sessions than the mindfulness meditation group, $F(1,29)=5.17$, $p=.031$, $g=0.81$. There was no significant difference between the groups in total amount of minutes spent training, $F(1,29)=1.31$, $p=.262$, $g=0.40$.

Table 2.

Descriptive Statistics for Expectancy Ratings and Training Adherence for the Relaxation and Mindfulness Groups.

	Relaxation		Mindfulness	
Variable	*M(SD)*	95% CI [*LL*,*UL*]	*M(SD)*	95% CI [*LL*, *UL*]
Expectancy				
Attention	7.25 (0.93)	[6.75, 7.75]	6.43 (1.39)	[5.62, 7.24]
Computer Tasks	6.06 (1.73)	[5.14, 6.98]	5.79 (1.88)	[4.70, 6.88]
Emotional	7.38 (1.20)	[6.73, 8.02]	6.64 (1.78)	[5.61, 7.67]
Training Adherence				
Days	6.75 (0.45)	[6.51, 6.99]	6.35 (0.74)	[5.92, 6.79]
Sessions	14.75 (7.25)	[10.88, 18.61]	10.21 (1.80)	[9.17, 11.25]
Total Minutes	146.88 (55.96)	[117.05, 176.70]	127.86 (28.70)	[111.29, 144.43]

Note. CI= confidence interval; *LL*= lower limit; *UL*= upper limit.

Secondary Outcome Measures

Descriptive statistics for the S-DERS, CAMS-R, MAAS, and POMS are shown in Table 3. There was a trend towards a significant decrease in the State Difficulties in Emotional Regulation Scale (S-DERS) from Session 1 (*M*=36.35, *SD*=6.74) to Session 2 (*M*=34.13, *SD*=6.98), $F(1, 29)=3.93$, $p=.057$, $g=.32$. However, there was no significant Group x Time interaction, $F(1, 29)=.07$, $p=.793$, $\eta_p^2=.002$, indicating that emotional regulation improved for both groups from Session 1 to Session 2. There was no significant difference in POMS from Session 1 to Session 2, $F(1,29)=0.37$, $p=.546$, $\eta_p^2=.013$, g=.07, and no significant Time x Group interaction, $F(1,29)=0.17$, $p=.681$, $\eta_p^2=.006$. There was no significant difference in scores on the CAMS-R between Session 1 and Session 2, $F(1,29)=3.11$, $p=.089$, $g=.22$, or Time x Group interaction, $F(1, 29)=0.08$, $p=.780$, $\eta_p^2=0.003$. There was no significant difference in mindfulness (MAAS) from Session 1 to Session 2, $F(1, 29)=0.17$, $p=.677$, $\eta_p^2=.006$, g=0.06, and no significant Time x Group interaction, $F(1, 29)=2.27$, $p=.268$, $\eta_p^2=.042$.

Table 3.

Descriptive Statistics for the S-DERS, POMS, CAMS-R, and MAAS at Session 1 and Session 2 for the Relaxation and the Mindfulness Groups

	Group							
	Relaxation				Mindfulness			
	Session 1		Session 2		Session 1		Session 2	
Measure	*M(SD)*	95%CI[*LL*,*UL*]	*M(SD)*	95%CI[*LL*,*UL*]	*M(SD)*	*95%CI[LL,UL]*	*M(SD)*	*95%CI[LL,UL]*
S-DERS	36.9 (7.6)	[32.9, 40.1]	35.0 (7.5)	[31.0, 38.9]	35.7 (5.8)	[32.5, 38.9]	33.2 (6.5)	[29.6, 36.8]
POMS	22.0 (13.1)	[15.0, 28.9]	23.7 (16.5)	[14.9, 32.5]	17.9 (6.0)	[14.6, 21.3]	18.3 (7.3)	[14.2, 22.3]
CAMS-R	29.5 (4.4)	[27.1, 31.9]	30.6 (4.3)	[28.3, 32.8]	30.6 (4.7)	[27.9, 33.2]	32.1 (4.2)	[29.8, 34.4]
MAAS	3.6 (1.0)	[3.1, 4.2]	3.8 (0.9)	[3.1, 4.3]	3.8 (0.7)	[3.4, 4.1]	3.7 (0.7)	[3.3, 4.1]

Note. CI=confidence interval; *LL*=lower limit; *UL*=upper limit.

Visual Analogue Scales

Descriptive statistics for the Visual Analogue Scales (VAS) are shown in Table 4. For the univariate tests, there was no significant effects for Time, or for the Time x Group interaction. For the main effect of Prepost (Bonferroni corrected α=.005), there was a significant difference in subjective ratings of Calm, $F(1, 17)=15.79$, $p<.001$, $\eta p2 = .37$, $g=0.20$. Calm was higher after focused breathing ($M=1.58$, $SD=1.13$) than before focused breathing ($M=2.58$, $SD=1.54$). Present focused was significantly higher post focused breathing task ($M=3.00$, $SD=1.49$) than before the focused breathing task ($M=3.74$, $SD=1.48$), $F(1, 17)=16.14$, $p<.001$, $\eta p2= .374$, $g=0.48$.

Table 4.

Descriptive Statistics for the Visual Analogue Scales for Pre and Post Focused Breathing Task at Session 1 and Session 2 for the Relaxation and Mindfulness Groups

		Relaxation		Mindfulness	
		Session 1	Session 2	Session 1	Session 2
Measure	Prepost	*M (SD)*	*M(SD)*	*M(SD)*	*M(SD)*
Alert	Pre	3.65 (2.35)	3.10 (1.82)	4.70(2.54)	3.81 (1.80)
	Post	2.84 (1.56)	3.04 (2.14)	4.55 (2.44)	4.53(2.50)
Distracted	Pre	5.87 (2.61)	5.67 (2.76)	5.27 (2.39)	5.50 (2.18)
	Post	6.10 (2.23)	6.72 (2.68)	5.24 (2.20)	5.81 (2.45)
Calm	Pre	2.52 (1.74)	2.60 (1.76)	2.85(2.15)	2.37 (1.57)
	Post	1.47 (0.92)	1.66(1.60)	1.76 (1.63)	1.42 (1.18)
Stressed	Pre	6.50 (2.66)	6.07 (2.15)	1.42 (1.18)	7.04 (2.20)
	Post	6.46 (2.41)	6.42 (2.40)	7.45 (2.01)	7.99 (1.69)
Accepting	Pre	2.31 (1.50)	2.79 (1.69)	3.09 (1.76)	3.25 (1.71)
	Post	2.00 (1.28)	2.33 (1.57)	2.65 (1.83)	2.53 (1.82)
Aware	Pre	2.97 (2.54)	2.73 (1.65)	3.57 (2.14)	3.69 (1.97)
	Post	2.54 (1.30)	2.49 (1.76)	4.03 (1.86)	3.34 (2.35)
Present-focused	Pre	3.40 (2.57)	3.59 (1.69)	4.35 (1.60)	3.61 (1.61)
	Post	2.41 (1.35)	2.89 (1.93)	3.31 (1.37)	3.39 (1.83)
Disinterested	Pre	5.97 (2.74)	6.10 (2.25)	6.47 (2.01)	6.80 (1.79)
	Post	7.14 (2.01)	7.02 (2.13)	5.87 (1.56)	6.53 (1.96)
Fatigued	Pre	5.45 (2.70)	5.40 (2.57)	4.32 (2.51)	5.30 (2.01)
	Post	4.96 (2.67)	5.36 (2.70)	4.15 (2.38)	4.36 (2.04)
Attentive	Pre	3.46 (3.00)	3.39 (1.92)	4.23 (2.37)	3.99 (1.39)
	Post	3.10 (1.46)	2.62 (1.68)	3.74 (1.16)	3.75 (1.63)

Note. CI=confidence interval; *LL*=lower limit; *UL*=upper limit.

Frontal Midline Theta

For the frontal midline theta Mixed Linear Models Analysis, a comparison between compound symmetry (-2LL(14)=612.66) and unstructured (-2LL(33)=462.33) covariance structures revealed a significant improvement in model fit for the unstructured model, χ2change(19)=150.33, p<.001. Additionally, the unstructured model offered a lower BIC value (634.24) compared to the compound symmetry model (658.59). These values indicate that even after accounting for model complexity, that the unstructured model offered the best fit for the data. Therefore, the unstructured covariance structure was used in the final analysis.

Table 5 displays the cell means and 95 % confidence intervals for frontal midline theta. The main effect of Group was non-significant, *F*(1, 32.58)=.66, *p*=.422, *g*=0.25, along with the main effect of Time, *F*(1, 30.04)=.41, *p*=.531, *g*=0.11. The main effect of Condition was significant, *F*(2, 31.29)=26.16, *p*<.001, with highest frontal midline theta in the eyes closed condition (*M*= 3.12, 95%CI[2.44, 3.79]), followed by the focused breathing condition (*M*=3.03, 95%CI[2.46, 3.60]), then the eyes open condition (*M*=2.41, 95%CI[1.87, 2.95]). Pairwise comparisons (Bonferroni corrected α=.017) revealed that frontal midline theta was significantly higher in the eyes closed rest and focused breathing condition compared to the eyes closed condition (*p*<.001), but there was no significant difference between the eyes closed condition and the focused breathing condition (*p*=.531).

The Group x Time interaction was not significant, *F*(1, 30.04)=.29, *p*=.595, along with the Time x Condition interaction, *F*(2, 31.05)=.28, *p*=.755, the Group x Condition interaction, *F*(2, 31.29)=1.34, *p*=.277, and the hypothesised Group x Time x Condition, *F*(2, 31.50)=1.75, *p*=.190.

Table 5.

Means and 95% CIs for Frontal Midline Theta at Session 1 and Session 2 in the Eyes open, Eyes closed, and Focused breathing condition for the Mindfulness and Relaxation groups

		Group			
		Relaxation		Mindfulness	
Session	Condition	*M*	95%CI[*LL*,*UL*]	*M*	95%CI[*LL*,*UL*]
Session 1	Eyes open	2.55	[1.84, 3.27]	2.58	[1.70, 3.47]
	Eyes closed	3.06	[2.32, 3.80]	3.82	[2.47, 5.17]
	Focused breathing	3.14	[2.33, 3.96]	3.32	[2.39, 4.25]
Session 2	Eyes open	2.18	[1.43, 2.94]	2.30	[1.36, 3.24]
	Eyes closed	2.87	[2.10, 3.64]	2.70	[1.26, 4.15]
	Focused breathing	2.76	[1.91, 3.61]	2.88	[1.90. 3.88]

Note. CI=confidence interval; *LL*=lower limit, *UL*=upper limit.

Frontal Theta/Beta Ratio

For frontal TBR, a comparison between compound symmetry (-2LL(14)=936.823) and unstructured (-2LL(33)=846.844) covariance structures revealed a significant improvement in model fit with the unstructured covariance structure, χ2change(19)=89.98, p<.001. Additionally, the unstructured model offered a lower BIC value (846.84) compared to the compound symmetry model (936.82). Therefore, the unstructured covariance structure was used in the final analysis.

Table 6 displays the cells means and 95 % confidence intervals for TBR. The main effect of Group was not significant, *F*(1, 32.18)=.85, *p*=.365, *g*=0.27, along with the main effect of Time, *F*(1, 30.59)=.03, *p*=.861, *g*=0.02.

The main effect of Condition was significant, *F*(2, 32.40)=8.30, *p*=.001. TBR was highest in the eyes closed condition (*M*=9.97, 95%CI[7.77, 12.16]), followed by focused breathing condition (*M*=9.64, 95%CI[7.35, 11.92]), and then the eyes open condition (*M*=8.35, 95%CI[6.61, 10.09]). Pairwise comparisons (Bonferroni corrected α=.017) revealed that Frontal TBR was significantly higher in the eyes closed condition (p<.001) and focused breathing condition (p=.011) than the eyes open condition, however there was no significant difference in frontal TBR between the focused breathing condition and the eyes closed condition (p=.372).

The Group x Time interaction was not significant, $F(1, 30.85)$=.044, p=.836, along with the Group x Condition interaction, $F(2, 32.40)$=1.19, p=.318, the Time x Condition interaction, $F(2, 31.88)$=1.90, p=.166, and the hypothesised Group x Time x Condition interaction, $F(2, 31.88)$=1.76, p=.188.

Table 6.

Means and 95% CIs for Frontal Theta/Beta Ratio at Session 1 and Session 2 in the Eyes open, Eyes closed, and Focused breathing condition for the Mindfulness and Relaxation groups

		Group			
		Relaxation		Mindfulness	
Session	Condition	*M*	95%CI[*LL*,*UL*]	*M*	95%CI[*LL*,*UL*]
Session 1	Eyes open	9.37	[6.69, 12.04]	8.97	[6.71, 11.23]
	Eyes closed	10.01	[6.78, 13.25]	11.29	[8.18, 14.40]
	Focused breathing	11.04	[7.73, 14.36]	10.73	[7.59, 13.87]
Session 2	Eyes open	7.74	[4.90, 10.58]	7.33	[4.93, 9.74]
	Eyes closed	9.22	[5.81, 12.63]	9.35	[6.04, 12.66]
	Focused breathing	8.26	[4.75, 11.78]	8.50	[5.16, 11.84]

Note. CI= confidence interval; *LL*= lower limit, *UL*= upper limit.

Alpha Band Power

A compound symmetry covariance structure was used to analyse alpha power as there was a failure to converge using an unstructured covariance structure. The failure to converge is likely due to the large number of parameters and the small sample size (Jahng & Wood, 2017).

Table 7 displays the cells means and 95 % CIs for alpha power. The main effect of Group was significant, $F(1, 32.03)=4.21$, $p=.049$, $g= 0.59$. The control condition had higher alpha power ($M=4.81$, 95%CI [3.26, 6.37]) than the experimental condition ($M=2.52$, 95%CI [0.87, 4.18]). A pairwise comparison comparisons (Bonferroni corrected $\alpha=.025$) found that this was not a significant difference ($p=.049$). The main effect of Time was not significant, $F(1, 518.84)=.078$, $p=.780$, $g=0.04$.

The main effect of Condition was significant, *F*(2, 517.03)=58.26, p<.001. Pairwise comparisons (Bonferroni corrected α=.017) revealed that Alpha was significantly higher in the Eyes closed (*M*=4.35, 95%CI[3.20, 5.51]) and Focused breathing conditions (*M*=4.17, 95%CI [3.02, 5.32]) than the Eyes open condition (*M*=2.49, 95%CI[1.33, 3.64] (*p*<.001), but there was no significant difference between the Eyes closed and Focused breathing conditions, (*p*=.341).

The Group x Condition interaction was significant, *F*(2, 517.03)=7.59, *p*=.001. Pairwise comparisons (Bonferroni corrected α=.008) revealed that there was no significant difference in the Eyes open condition between the Relaxation group (*M*=3.21, 95%CI[1.63, 4.79]) and the Mindfulness group (*M*=1.76, 95%CI[.08, 3.45]) (*p*=.212), and in the Eyes closed condition between the Relaxation group (*M*=5.78, 95%CI[4.20, 7.37]) and the Mindfulness group (*M*=2.92, 95%CI[1.24, 4.61]), *p*=.017. There was no significant difference in the Focused breathing condition between the Relaxation group (*M*=5.45, 95%CI[3.87, 7.03]) and the Mindfulness group (*M*=2.90, 95%CI[1.21, 4.58]), (*p*=.031). The hypothesised Group x Time x Condition interaction was not significant, *F*(2, 517.03)=.500, *p*=.607.

Table 7.

Means and 95% CIs for Alpha power at Session 1 and Session 2 in the Eyes open, Eyes closed, and Focused breathing condition for the Mindfulness and Relaxation groups

		Group			
		Relaxation		Mindfulness	
Session	Condition	*M*	95%CI[*LL*,*UL*]	*M*	95%CI[*LL*,*UL*]
Session 1	Eyes open	2.97	[1.35, 4.59]	3.44	[1.82, 5.07]
	Eyes closed	5.91	[4.29, 7.53]	5.66	[4.04, 7.28]
	Focused breathing	5.51	[3.89, 7.13]	5.39	[3.77, 7.01]
Session 2	Eyes open	1.74	[0.02, 3.46]	1.78	[0.05, 3.51]
	Eyes closed	2.91	[1.19, 4.63]	2.94	[1.21, 4.66]
	Focused breathing	3.11	[1.39, 4.83]	2.67	[0.95, 4.40]

Note. CI= confidence interval; *LL*= lower limit; *UL*= upper limit.

Discussion

The present study aimed to examine whether electrophysiological changes occur after one week of mindfulness meditation training with neurofeedback. The hypotheses that alpha and frontal midline theta band power would increase, and frontal theta/beta ratio would decrease, in the focused breathing task from Session 1 to Session 2 for the mindfulness meditation group in comparison to the control group were unsupported. It was found that there was no change in frontal midline theta power, alpha power, and frontal TBR, from Session 1 to Session 2 for both groups.

The hypotheses that alpha and theta power will be lowest in the eyes open condition, and higher in the eyes closed condition, followed by the focused breathing condition, and that frontal TBR would decrease in the focused breathing task, were unsupported. Alpha and theta power were higher in the eyes closed and focused breathing conditions than the eyes closed condition, but there was no difference between the two eyes closed conditions. Frontal TBR was highest in the eyes closed and focused breathing conditions but decreased in the eyes open condition.

For the outcome measures, the hypotheses that there would be an increase in scores on the MAAS and CAMS-R, indicating increased mindfulness, and a decrease in S-DERS and the STAI-S, indicating a reduction in difficulties in emotional regulation and state anxiety, for the mindfulness meditation group in comparison to the relaxation group, were unsupported. There were no differences between the groups in these measures from Session 1 to Session 2. However, there was a trend towards a significant decrease with a small effect size in difficulties in emotional regulation (S-DERS) for both groups from Session 1 to Session 2.

Frontal Midline Theta

The finding that there was no change in frontal midline theta power from Session 1 to Session 2 for the mindfulness meditation with neurofeedback condition in comparison to the relaxation with biofeedback condition is inconsistent with previous research. Increased frontal midline during meditation has been observed during meditation in cross sectional studies with experienced meditators during meditation compared to a resting condition (Aftanas & Golocheikine, 2001; Baijal & Srinivasan, 2010) and in longitudinal studies after six weeks of mindfulness meditation practice (Ahani et al., 2014), and after five days of Integrative Mind Body Practice (IMBT) (Tang et al., 2009).

However, it is consistent with research which has found no change or a decrease in theta power during meditation in novice meditators (Dunn et al., 1999; Yu et al., 2011). It has been suggested that the decrease in theta observed during meditation for novice meditators may be due to limited meditation experience, as studies have found a positive correlation between theta activity and amount of meditation experience (Fell et al., 2010; Murata et al., 1994; Yu et al., 2011). Therefore, the lack of change in theta power observed in this study, may suggest that the mindfulness meditation dose was insufficient to cause training related changes.

Research has also found that different stages of the meditative practice are associated with distinct neurophysiological changes. Frontal midline theta increases are associated with subjective meditation depth, whilst alpha is observed in all stages of meditation regardless of depth of meditation (DeLosAngeles et al., 2016). As this study only included five minutes of focused breathing time, it is possible that this was not enough time to reach a deeper meditative state.

Alpha Band Power

The finding that alpha band power did not increase in the focused breathing task from Session 1 to Session 2 for the mindfulness meditation group was inconsistent with previous research. Increases in alpha power during meditation have been observed during mindfulness meditation after six weeks of training (Ahani et al., 2014), and after 16 weeks of training (Dunn et al., 1999). However, the results are consistent with suggestions that the increased alpha power observed in some studies reflects increased relaxation in those proficient in meditation, as other studies which have controlled for relaxation have not found increased alpha during meditation (Cahn & Polich, 2006). It is thought that increases in alpha band power during meditation indicate that a meditator has reached a relaxed and alert stage which is required before they can progress to a deeper stage of meditation (Tang, Tang, Rothbart, & Posner, 2019). It is possible that as the focused breathing task in the current study only lasted five minutes that it was not a sufficient amount of time to reach a relaxed state.

Theta/Beta Ratio

A decrease in theta/beta ratio (TBR), indicating an improvement in attentional control, in the focused breathing condition from Session 1 to Session 2 for the mindfulness meditation group was not observed. Furthermore, the hypothesis that TBR would decrease in the focused breathing condition, as this requires attentional control to focus attention on the breath, was unsupported. It was found that TBR was increased in the focused breathing condition and eyes closed condition compared to the eyes open condition, suggesting increased mind wandering and reduced attentional control in these conditions.

This finding is inconsistent with other studies which found that during a 20 minute breath counting task, TBR is higher during mind wandering episodes (van Son et al., 2019a; van Son et al., 2019b). The inconsistency between the findings in these studies and the current study, could be due to differences between the tasks used. In the other studies, participants were asked to count their breath cycle from one to ten and to press a button when they noticed they had lost count. However, in the current study participants were asked to focus their attention on the sensation of the breath, rather than count their breath, which is a task that likely requires less attentional control and focus. Furthermore, using the button press paradigm provided the researchers with a more detailed understanding of what was happening during the breath counting task. However, in the current study it is difficult to establish at what points a participant was experiencing mind wandering or using attentional control as this was averaged over the five-minute period. It is possible that for naïve meditators it may have been too difficult for them to focus on their breath without counting and having their eyes open and focused on the fixation point may have decreased overall mind wandering as they had something to visually focus on.

Although, to our knowledge, no previous studies have examined changes in TBR associated with mindfulness meditation practice in a randomised controlled trial, the lack of change in TBR after the mindfulness meditation intervention is inconsistent with findings in previous research. One study found that after 20 weeks of a mindfulness-based martial arts program, children diagnosed with ADHD had a decrease in TBR during a Go/No-Go task (Sibalis et al., 2019). However, there are important differences between this study and the current study. The current study involved a shorter intervention, a healthy population, and only included mindfulness meditation with neurofeedback, whilst the other study included confounding variables, such as exercise and group classes which may affect attention (Sibalis et al., 2019).

TBR has only been identified as a potential neurophysiological measure of attentional control and some studies have not found a negative correlation between TBR and self-reported attentional control (Angelidis et al., 2018; Morillas-Romero, Tortella-Feliu, Bornas, & Putman, 2015). In addition, a limitation of literature in this area is the reliance on self-reported measures, as research has found that there are only small correlations between self-reported AC and behavioural measures of AC (Muris, van der Pennen, Sigmond, & Mayer, 2008; Reinholdt-Dunne, Mogg, & Bradley, 2013).

Possible Explanations for Null Results

A potential explanation of the lack of electrophysiological changes after the intervention, is that the dose of meditation was insufficient. In comparison to most studies in this area, which investigate longer term meditation interventions, this study examined the effects of a short-term mindfulness meditation intervention consisting of seven days of 20-minute sessions. Research has not established what constitutes the minimum amount of meditation needed to observe training related changes, and it has been acknowledged that this is an important area for future research (Bhayee et al., 2016; Slagter et al., 2011; Van Dam et al., 2018).

However, some studies have observed changes in electrophysiological measures after brief meditation interventions. It was found that after five days of 20-minute Integrative Body-Mind Training (IBMT), there was a significant increase in frontal midline theta power during meditation (Tang et al., 2009), and improvements in executive attention and mood (Tang et al., 2007). Tang et al. (2007) suggest that a possible explanation for the efficacy of IBMT in improving executive attention and mood over a brief period may be because the technique integrates other factors such as body relaxation, breath adjustment, and mental imagery along with mindfulness training. As each of these elements are individually associated with improvements in mood and attention, using a combination of them may lead to more rapid changes than utilising one technique (Tang et al., 2007). As these studies incorporate other elements apart from mindfulness and meditation, it could suggest that mindfulness is not the causal mechanism behind the changes. Measures of mindfulness were also not used in these studies to ascertain whether mindfulness increased after the intervention. In the current study, the lack of change in the mindfulness measures from Session 1 to Session 2, indicates that mindfulness did not increase after a week of 20-minute mindfulness meditation sessions.

There are also factors associated with the experimental design which may have influenced participants ability to reach a meditative state during the focused breathing task. Experimental sessions lasted approximately two hours. Participants first completed questionnaires, EEG set up commenced, and then completion of an Emotional Stroop Task and the Attentional Network Task before completing the focused breathing task. In designing the experiment, we elected to have the focused breathing task at the end of the session, because completing meditation may induce state changes which could influence performance in other tasks. However, it is possible that by the time participants commenced the focused breathing task that they were quite fatigued. Current level of sleepiness was measured by the

KSS. However, this was conducted at the beginning of the experimental session and may not be reflective of the level of sleepiness before commencing the focused breathing task. Furthermore, the room where the experiment was conducted was warm, quiet, and dimly lit.

The focused breathing task involved one five-minute block of rest with open eyes, one five-minute block of rest with eyes closed, then one five-minute block of focused breathing designed to induce a meditative state but be achievable for naïve meditators. In designing the focused breathing task, we elected to place the five-minute block of focused breathing at the end of the task to prevent state effects from the meditative state influence the other blocks instead of counterbalancing the conditions. It may have not been long enough to enter a meditative state. It is also possible that after ten minutes of two blocks that were quite similar, participants were not concentrating or invested when completing the focused breathing task.

The VAS were included as a control measure. It was found that subjective ratings of calmness and feeling present focused were higher after the task than before the task. As subjective experiences of calm and being present focused are associated with mindfulness meditation practice, this suggests that participants were completing mindfulness meditation during their task. However, the VAS were completed before commencing the five-minute eyes open rest and after the focused breathing task. Therefore, it is possible that changes were related to the eyes open and eyes closed conditions and not just the focused breathing condition.

Limitations and Directions for Future Research

One of the limitations of this study is that it is difficult to establish the effects of the neurofeedback. The current study did not include a group that completed mindfulness meditation without neurofeedback, therefore it is hard to establish whether the neurofeedback enhanced or impeded mindfulness meditation practice. Furthermore, the Muse company does not disclose the algorithm that it uses to define focused or unfocused brain states. It is possible that the mindfulness meditation group were being encouraged to produce brain waves which did not reflect the meditative state observed in other mindfulness meditation studies. Bhayee et al. (2016) note that currently there is no clear agreement on the best algorithm for these devices. However, their study found that after six weeks of 10 minutes daily mindfulness meditation training with the Muse device, that there were improvements in wellbeing and attention consistent with changes observed after traditional mindfulness meditation programs (Bhayee et al., 2016). Furthermore, a study comparing a group meditating with the Muse device with a group meditating without neurofeedback, found the Muse group had improved cognitive performance, and increased in alpha/beta ratio at rest, in comparison to the group without neurofeedback after four weeks of daily 10-minute training (Crivelli et al., 2018). However, these programs were over a longer duration than our study. Furthermore, participants recruited for the Bhayee et al. (2016) experiment were classified as healthy but under moderate to high levels of stress and participants recruited for the Crivelli et al. (2018) experiment were under mild stress. In comparison, in our study, we did not specifically aim to recruit participants experiencing stress.

Although our study was not able to establish the effect of neurofeedback, there are several benefits of including technology-assisted device in mindfulness meditation research and our study contributes to research on these devices by including a control condition that received biofeedback. It addressed several limitations of other studies by providing an active control group, which according to the training expectancy measures, were matched in terms of expectancy that the intervention would improve attention, ability to complete computer tasks, and wellbeing.

Another advantage of using neurofeedback and biofeedback devices with associated apps is that all session and progress are recorded, therefore the current study was able to reliably record the time participants spent in the intervention. This offered an advantage over other studies examining home-based mindfulness meditation studies which rely on retrospective self-reporting of meditation time, as these self-reports can be biased by recall difficulties, fabrication, or estimation (Davidson & Kaszniak, 2015).

One possible option for future research is to use covariate analyses to examine which factors are associated with improvements in the outcomes of interest. For example, Muse collects information on the number of birds heard during meditation (indicating a person has focused their attention for an extended period of time), calm points (awarded for spending time in a neutral or calm state), and recoveries (when mind wandering is detected and the person refocuses their attention). Future studies could examine whether a participant's score in these measures mediate or moderate electrophysiological measures and outcome measures.

Future studies could also consider including a group who engages in a mindfulness meditation intervention without neurofeedback to delineate the effects of the neurofeedback from the mindfulness meditation, to increase the dose of meditation by either time spent meditating each day or duration of the intervention, and the increase the length of the focused breathing task to allow participants more time to enter a meditative state.

Summary and Conclusions

The present study aimed to add to the understanding of the psychological and neuropsychological processes responsible for improvements in wellbeing and attention using mindfulness-based interventions by examining whether electrophysiological changes occur after one week of mindfulness meditation training with neurofeedback. It was found that there were no changes in alpha power, frontal midline theta power, and frontal theta/beta ratio from Session 1 to Session 2 for the mindfulness meditation with neurofeedback group and the relaxation with biofeedback group. A potential explanation for these results is that the dose of meditation the experimental group received was not sufficient to lead to training related changes in electrophysiological measures. Measures of mindfulness did not change from Session 1 to Session 2, indicating that the intervention did not increase mindfulness for the experimental group. It is also possible that the focused breathing task was not long enough to allow participants to enter a meditative state.

Despite the null findings, this study makes a valuable contribution to the existing literature. The study design addresses limitations identified in other meditation studies, such as the use of cross-sectional design, lack of active control groups, interventions which include confounding variables, and study designs which confuse the state and trait effects of meditation, by conducting a randomised controlled longitudinal study of participants with low meditation experience. Specifically, it adds to the existing literature on neurofeedback-assisted, technology-supported mindfulness training interventions by including an active control group who also had a biofeedback device to control for expectancy effects. It also provides further insight into important methodological considerations, such as dose in mindfulness meditation interventions and task design when measuring meditative states in novice meditators, when conducting research on mindfulness meditation.

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List of Appendices

Appendix A

Online Screening Questionnaire

Demographics
Please enter your first name _________________.
Please enter your email address _________________.
Please enter your phone number _________________.
How old are you? _________________.
What is your biological sex? Male: ☐ Female: ☐ No answer: ☐
Are you right or left handed? Right: ☐ Left: ☐ No answer: ☐
Is English your first language? Y: ☐ N: ☐ No answer: ☐
Are you currently pregnant or trying to become pregnant? Y: ☐ N: ☐ No answer: ☐
Health
Do you have sensitive skin? Y: ☐ N: ☐ No answer: ☐
Have you ever experienced (or been diagnosed with) any of the following: Epilepsy Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Fits / seizures Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Regular giddiness/fainting Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Severe / multiple concussions Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Severe head injury Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Brain surgery Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Loss of consciousness (more than 2 minutes) Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Diabetes Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Heart Condition Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Sleep disorder (or any major sleeping difficulties) Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Visual problems (not corrected by glasses/lenses) Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Auditory problems Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Any other serious physical condition Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Any other neurological condition Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ ADHD/ADD Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Dyslexia Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Learning difficulties Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Current depression / anxiety Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Past depression / anxiety Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐ Other mental health conditions (e.g., mania, psychosis, schizophrenia, PTSD, OCD, substance dependence etc) Y: ☐ N: ☐ Uncertain: ☐ No answer: ☐
If you answered yes or uncertain to any of the above, please provide some brief details (or the researchers can ask by phone if you prefer): ________________________________
Are you currently taking any prescribed medications? Y: ☐ N: ☐ No answer: ☐ If yes, please list the name of the medications: _____________________________________ ____.

Substance use

The following questions are about your use of tobacco and alcohol

In the last 6 months, how often have you used tobacco/nicotine?

Never 0
Less than monthly 1
Monthly 2
Weekly 3
Daily or almost daily 4

AUDIT

Q1. How often do you have a drink containing alcohol?

Never..0
(Go to Q9)
Monthly or less...............................1
2–4 times per month.........................2
2–3 times per week...........................3
4 or more times a week.....................4

Q2. How many drinks containing alcohol do you have on a typical day when you are drinking?

1 or 2...0
3 or 4...1
5 or 6...2
7 to 9...3
10 or more 4

Q3. How often do you have six or more drinks on one occasion?

Never...0
Less than monthly.............................1
Monthly..2
Weekly 3
Daily or almost daily 4

Q4. How often during the last year have you found that you were unable to stop drinking once you had started?

Never...0
Less than monthly.............................1
Monthly..2
Weekly 3
Daily or almost daily 4

Q5. How often during the last year have you failed to do what was normally expected from you because of drinking?

Never...0
Less than monthly.............................1
Monthly..2
Weekly 3
Daily or almost daily 4

Q6. How often during the last year have you needed a first drink in the morning to get yourself going, after a heavy drinking section?

Never...0
Less than monthly.............................1
Monthly..2
Weekly 3
Daily or almost daily 4

Q7. How often during the last year have you had a feeling of guilt or remorse after drinking?

Never...0
Less than monthly.............................1
Monthly..2
Weekly 3
Daily or almost daily 4

Q8. How often during the last year have you been unable to remember what happened the night before because you had been drinking?

Never...0
Less than monthly.............................1
Monthly..2
Weekly 3
Daily or almost daily 4

Q9. Have you or someone else been injured as a result of your drinking?

No...0
Yes, but not in the last year 2
Yes, during the last year 4

Q10. Has a relative or friend or doctor or other health worker been concerned about your drinking or suggested you cut down?

No...0
Yes, but not in the last year 2
Yes, during the last year 4

Kessler Psychological Distress scale (K10)

In the last 4 weeks, about how often:

1. Did you feel tired out for no good reason?

All of the time.......................................1
Most of the time...................................2
Some of the time.................................3
A little of the time.................................4
None of the time 5

2. Did you feel nervous?

All of the time.......................................1
Most of the time.................................2
Some of the time................................3
A little of the time................................4
None of the time 5

Note: If response 5 chosen, go to Q4

3. Did you feel so nervous that nothing could calm you down?

All of the time..1
Most of the time....................................2
Some of the time...................................3
A little of the time...................................4
None of the time 5

4. Did you feel hopeless?

All of the time..1
Most of the time......................................2
Some of the time.....................................3
A little of the time.....................................4
None of the time 5

5. Did you feel restless or fidgety?

All of the time..1
Most of the time......................................2
Some of the time.....................................3
A little of the time.....................................4
None of the time 5

Note: If response 5 chosen, go to Q7

6. Did you feel so restless that you could not sit still?

All of the time..1
Most of the time.......................................2
Some of the time......................................3
A little of the time......................................4
None of the time......................................5

7. Did you feel depressed?

All of the time.......................................1
Most of the time..................................2
Some of the time..................................3
A little of the time..................................4
None of the time..................................5

8. Did you feel that everything was an effort?

All of the time...................................1
Most of the time...............................2
Some of the time..............................3
A little of the time..............................4
None of the time 5

9. Did you feel so sad that nothing could cheer you up?

All of the time.......................................1
Most of the time..................................2
Some of the time..................................3
A little of the time..................................4
None of the time 5

10. Did you feel worthless?

All of the time.....................................1
Most of the time..................................2
Some of the time.................................3
A little of the time.................................4
None of the time 5

STAI - Trait Anxiety

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name____ Date________

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate value to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	1	2	3	4
22. I feel nervous and restless	1	2	3	4
23. I feel satisfied with myself	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I feel like a failure	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I have disturbing thoughts	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I make decisions easily	1	2	3	4
35. I feel inadequate	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bothers me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

Meditation / Relaxation Experience Questionnaire

Have you had any experience with the following forms of meditation/relaxation?

	Yes	**No**
Mindfulness training (including MBSR MBCBT, IBMT, MiCT, ACT, etc)		
Zen		
Vipassana		
Shamatha		
Vipashyana		
Shavasana		
Meditative contemplation		
Sadhana		
Mahamudra		
Breathing meditation		
Walking meditation		
Compassion meditation (tonglen, metta, loving, kindness, etc.)		
Ngondro		
TM		
Tai Chi		
Yoga		
Qigong		
Relaxation exercises (e.g., progressive muscle relaxation)		
Other…………… (please specify)		

In the past year, how much time have you spent practicing any form of meditation / relaxation per week?

None
Less than 15 mins
15-30 mins
30-60 mins
1-2 hours
2-5 hours
More than 5 hours

Which forms of meditation / relaxation have you practiced in the past year?

____

In your lifetime, how many hours have you spent practicing meditation / relaxation?

None
Less than 1 hours
1-5 hours
5-10 hours
10-20 hours
More than 20 Hours

Which forms of meditation / relaxation have you practiced for more than 5 hours in your lifetime?

____

Video Game Playing Questionnaire – *DURING* THE PAST YEAR

Ss ID: ____ Date: ________________

For each category of games, please rate:

1. Your estimated EXPERTISE in that category (1 = lowest, 7 = highest) – even if no experience, how do you think you would perform, compared to the general public?
2. Your average HOURS PER WEEK in that category for the past 12 months. Ex: If you play 1.5 hrs/week, mark "1+ to 3"
3. The games you played and how old you were when you played them most

ACTION_FIRST/THIRD PERSON SHOOTERS (Call Of Duty, Halo, Battlefield, Half-Life, Overwatch, Counterstrike ...)
Expertise: **1 2 3 4 5 6 7** Hours per week: **Never 0+ to 1 1+ to 3 3+ to 5 5+ to 10 10+**
Games played most over the past year:

____

ACTION_RPG/ADVENTURE (The Witcher, Mass Effect, Fallout 4, Skyrim, GTA, Assassin's Creed, Tomb Raider, The Last of Us, ...)
Expertise: **1 2 3 4 5 6 7** Hours per week: **Never 0+ to 1 1+ to 3 3+ to 5 5+ to 10 10+**
Games played most over the past year:

____

SPORTS/DRIVING (Fifa, NHL, Mario Kart, Need for Speed, Forza, ...)
Expertise: **1 2 3 4 5 6 7** Hours per week: **Never 0+ to 1 1+ to 3 3+ to 5 5+ to 10 10+**
Games played most over the past year:

____

REAL-TIME STRATEGY/MOBA (Starcraft, Warcraft (old ones:I, II & III), DotA, Command & Conquer, League of Legends, Age of Empires, ...)
Expertise: **1 2 3 4 5 6 7** Hours per week: **Never 0+ to 1 1+ to 3 3+ to 5 5+ to 10 10+**
Games played most over the past year:

____

NON-ACTION TURN-BASED ROLE-PLAYING/FANTASY (Final Fantasy, Fable, Pokemon, Dragon Age, ...)
Expertise: **1 2 3 4 5 6 7** Hours per week: **Never 0+ to 1 1+ to 3 3+ to 5 5+ to 10 10+**
Games played most over the past year:

____

TURN-BASED STRATEGY/LIFE SIMULATION/PUZZLE (Civilization, Hearthstone, The Sims, Restaurant Empire, Puzzle Quest, Bejeweled, Solitaire, Candy Crush, ...)
Expertise: **1 2 3 4 5 6 7** Hours per week: **Never 0+ to 1 1+ to 3 3+ to 5 5+ to 10 10+**
Games played most over the past year:

____

MUSIC GAMES (Guitar Hero, Dance Dance Revolution, Rock Band, ...)
Expertise: **1 2 3 4 5 6 7** Hours per week: **Never 0+ to 1 1+ to 3 3+ to 5 5+ to 10 10+**
Games played most over the past year:

____

OTHER (Games that don't fit into any other category, Phone games, Browser games, Fighting games, etc.)
Expertise: **1 2 3 4 5 6 7** Hours per week: **Never 0+ to 1 1+ to 3 3+ to 5 5+ to 10 10+**
Games played most over the past year:

____

The mini International Personality Item Pool (IPIP) scale
Donnellan, M.B., Oswald, F.L., Baird, B.M., & Lucas, R.E. (2006).

Instructions: On the following pages, there are phrases describing people's behaviors. Please use the rating scale below to describe how accurately each statement describes you. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence. Please read each statement carefully, and then fill in the bubble that corresponds to the number on the scale.

1=Very Inaccurate
2=Moderately Inaccurate
3=Neither Inaccurate nor Accurate
4=Moderately Accurate
5=Very Accurate

1. Am the life of the party (E)
2. Sympathize with others' feelings (A)
3. Get chores done right away (C)
4. Have frequent mood swings (N)
5. Have a vivid imagination (I)
6. Don't talk a lot (E)
7. Am not interested in other people's problems (A)
8. Often forget to put things back in their proper place (C)
9. Am relaxed most of the time (N)
10. Am not interested in abstract ideas (I)
11. Talk to a lot of different people at parties (E)
12. Feel others' emotions (A)
13. Like order (C)
14. Get upset easily (N)
15. Have difficulty understanding abstract ideas (I)
16. Keep in the background (E)
17. Am not really interested in others (A)
18. Make a mess of things (C)
19. Seldom feel blue (N)
20. Do not have a good imagination (I)

Note: Items 6, 7, 8, 9, 10, 15, 16, 17, 18, 19, and 20 are reverse scored.

Appendix B

Experimental Session Questionnaire

Experimental Session Screening Questionnaire
Have you abstained from illicit drugs since first contact from the experimenter? Yes: ☐
Have you consumed alcohol within the last 24 hours? Yes: ☐ No: ☐
How many cups of coffee (or other caffeinated products) have you consumed today? ________________. If yes: many hours has it been since your last? ________________.
Have you had any tobacco or nicotine products today? Yes: ☐ No: ☐ *If yes:* how many cigarettes / nicotine products have you had today? ________________. *If yes:* how many hours since your last cigarette or nicotine product? ________________.
Have you consumed any medications in the past week) Yes: ☐ No: ☐ *If yes,* please detail: Medication Estimated dose Number of occasions taken Time since last taken 1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________
Are you an undergraduate psychology student completing this study for course credit? Yes: ☐ No: ☐

Appendix C

The State-Trait Anxiety Inventory (STAI)

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name______________________________ Date__________

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate value to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	1	2	3	4
22. I feel nervous and restless	1	2	3	4
23. I feel satisfied with myself	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I feel like a failure	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I have disturbing thoughts	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I make decisions easily	1	2	3	4
35. I feel inadequate	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bothers me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

Appendix D

The Five Facet Mindfulness Questionnaire (FFMQ-15)

FFMQ-15: 15-item Five-Facet Mindfulness Questionnaire

Instructions

Please use the 1 (never or very rarely true) to 5 (very often or always true) scale provided to indicate how true the below statements are of you. Circle the number in the box to the right of each statement which represents your own opinion of what is generally true for you. For example, if you think that a statement is often true of you, circle '4' and if you think a statement is sometimes true of you, circle '3'.

	Never or very rarely true	Rarely true	Sometimes true	Often true	Very often or always true
1. When I take a shower or a bath, I stay alert to the sensations of water on my body.	1	2	3	4	5
2. I'm good at finding words to describe my feelings.	1	2	3	4	5
3. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.	1	2	3	4	5
4. I believe some of my thoughts are abnormal or bad and I shouldn't think that way.	1	2	3	4	5
5. When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.	1	2	3	4	5
6. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.	1	2	3	4	5
7. I have trouble thinking of the right words to express how I feel about things.	1	2	3	4	5
8. I do jobs or tasks automatically without being aware of what I'm doing.	1	2	3	4	5
9. I think some of my emotions are bad or inappropriate and I shouldn't feel them.	1	2	3	4	5
10. When I have distressing thoughts or images I am able just to notice them without reacting.	1	2	3	4	5
11. I pay attention to sensations, such as the wind in my hair or sun on my face.	1	2	3	4	5
12. Even when I'm feeling terribly upset I can find a way to put it into words.	1	2	3	4	5
13. I find myself doing things without paying attention.	1	2	3	4	5
14. I tell myself I shouldn't be feeling the way I'm feeling.	1	2	3	4	5
15. When I have distressing thoughts or images I just notice them and let them go.	1	2	3	4	5

Baer, R. A., Carmody, J., & Hunsinger, M. (2012). Weekly change in mindfulness and perceived stress in a mindfulness-based stress reduction program. *Journal of Clinical Psychology, 68*(7), 755-765. doi: 10.1002/jclp.21865

Gu, J., Strauss, C., Crane, C., Barnhofer, T., Karl, A., Cavanagh, K., & Kuyken, W. (2016). Examining the factor structure of the 39-item and 15-item versions of the Five Facet Mindfulness Questionnaire before and after mindfulness-based cognitive therapy for people with recurrent depression. *Psychological assessment, 28*(7), 791. doi: 10.1037/pas0000263

Appendix E

The Wechsler Test of Adult Reading (WTAR)

wtar™ WORD CARD

WECHSLER® TEST OF ADULT READING™

1. again
2. address
3. cough
4. preview
5. although
6. most
7. excitement
8. know
9. plumb
10. decorate
11. fierce
12. knead
13. aisle
14. vengeance
15. prestigious
16. wreathe
17. gnat
18. amphitheater
19. lieu
20. grotesque
21. iridescent
22. ballet
23. equestrian
24. porpoise
25. aesthetic
26. conscientious
27. homily
28. malady
29. subtle
30. fecund
31. palatable
32. menagerie
33. obfuscate
34. liaison
35. exigency
36. xenophobia
37. ogre
38. scurrilous
39. ethereal
40. paradigm
41. perspicuity
42. plethora
43. lugubrious
44. treatise
45. dilettante
46. vertiginous
47. ubiquitous
48. hyperbole
49. insouciant
50. hegemony

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Appendix F

Karolinska Sleepiness Scale (KSS)

Karolinska Sleepiness Scale

Please circle on the following scale of 1 to 9 how you feel AT THE PRESENT MOMENT*:*

1. Extremely alert
2. Very alert
3. Alert
4. Rather alert
5. Neither alert nor sleepy
6. Some signs of sleepiness
7. Sleepy, but no effort to keep awake
8. Sleepy, some effort to keep awake
9. Very sleepy, great effort to keep awake, fighting sleep

Appendix G

Profile of Mood States-Short Form (POMS-SF)

Profile of Mood States-Short Form

Below is a list of words that describe feelings people have. Please read each one carefully. Then circle ONE answer to the right, which best describes how you are feeling AT THE MOMENT.

The numbers refer to these phrases:
0=not at all
1=a little
2=moderately
3=quite a bit
4= extremely

1. **Tense................0 1 2 3 4**
2. **Angry................0 1 2 3 4**
3. **Worn out..........0 1 2 3 4**
4. **Unhappy...........0 1 2 3 4**
5. **Lively................0 1 2 3 4**
6. **Confused..........0 1 2 3 4**
7. **Peeved..............0 1 2 3 4**
8. **Sad.....................0 1 2 3 4**
9. **Active................0 1 2 3 4**
10. **On Edge............0 1 2 3 4**
11. **Grouchy............0 1 2 3 4**
12. **Blue..................0 1 2 3 4**
13. **Energetic........ 0 1 2 3 4**
14. **Hopeless..........0 1 2 3 4**
15. **Uneasy.............0 1 2 3 4**
16. **Restless............0 1 2 3 4**
17. **Unable to Concentrate.....0 1 2 3 4**
18. **Fatigued...........0 1 2 3 4**
19. **Annoyed..........0 1 2 3 4**
20. **Discouraged............0 1 2 3 4**
21. **Resentful..................0 1 2 3 4**
22. **Nervous.....................0 1 2 3 4**
23. **Miserable..................0 1 2 3 4**
24. **Cheerful....................0 1 2 3 4**
25. **Bitter.........................0 1 2 3 4**
26. **Exhausted.................0 1 2 3 4**
27. **Anxious.....................0 1 2 3 4**
28. **Helpless....................0 1 2 3 4**
29. **Weary........................0 1 2 3 4**
30. **Bewildered...............0 1 2 3 4**
31. **Furious......................0 1 2 3 4**
32. **Full of pep.................0 1 2 3 4**
33. **Worthless.................0 1 2 3 4**
34. **Forgetful..................0 1 2 3 4**
35. **Vigorous...................0 1 2 3 4**
36. **Uncertain about things......................0 1 2 3 4**
37. **Bushed......................0 1 2 3 4**

Appendix H

The Cognitive and Affective Mindfulness Scale (CAMS-R)

The Cognitive and Affective Mindfulness Scale – Revised (CAMS-R)

The CAMS-R is a 12-item measure designed to capture a broad conceptualization of mindfulness with language that is not specific to any particular type of meditation training.

Feldman, G., Hayes, A., Kumar, S. et al. J Psychopathol Behav Assess (2007) 29: 177. doi:10.1007/s10862-006-9035-8

Instructions: People have a variety of ways of relating to their thoughts and feelings. For each of the items below, rate how much each of these ways applies to *you*.

_______ 1. It is easy for me to concentrate on what I am doing.
_______ 2. I am preoccupied by the future.
_______ 3. I can tolerate emotional pain.
_______ 4. I can accept things I cannot change.
_______ 5. I can usually describe how I feel at the moment in considerable detail.
_______ 6. I am easily distracted.
_______ 7. I am preoccupied by the past.
_______ 8. It's easy for me to keep track of my thoughts and feelings.
_______ 9. I try to notice my thoughts without judging them.
_______ 10. I am able to accept the thoughts and feelings I have.
_______ 11. I am able to focus on the present moment.
_______ 12. I am able to pay close attention to one thing for a long period of time.

Scoring: Items 2, 6, and 7 are reverse-scored. After appropriate reversals, sum values for items 1 - 12. Higher values reflect greater mindful qualities.

Appendix I

The Mindfulness Attention Awareness Scale (MAAS).

The Mindful Attention Awareness Scale (MAAS)

The trait MAAS is a 15-item scale designed to assess a core characteristic of mindfulness, namely, a receptive state of mind in which attention, informed by a sensitive awareness of what is occurring in the present, simply observes what is taking place.

Brown, K.W. & Ryan, R.M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84,* 822-848.

Carlson, L.E. & Brown, K.W. (2005). Validation of the Mindful Attention Awareness Scale in a cancer population. *Journal of Psychosomatic Research, 58,* 29-33.

Instructions: Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what you think your experience should be. Please treat each item separately from every other item.

1	2	3	4	5	6
almost always	very frequently	somewhat frequently	somewhat infrequently	very infrequently	almost never

_____ 1. I could be experiencing some emotion and not be conscious of it until some time later.
_____ 2. I break or spill things because of carelessness, not paying attention, or thinking of something else.
_____ 3. I find it difficult to stay focused on what's happening in the present.
_____ 4. I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.
_____ 5. I tend not to notice feelings of physical tension or discomfort until they really grab my attention.
_____ 6. I forget a person's name almost as soon as I've been told it for the first time.
_____ 7. It seems I am "running on automatic," without much awareness of what I'm doing.
_____ 8. I rush through activities without being really attentive to them.
_____ 9. I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.
_____ 10. I do jobs or tasks automatically, without being aware of what I'm doing.
_____ 11. I find myself listening to someone with one ear, doing something else at the same time.
_____ 12. I drive places on 'automatic pilot' and then wonder why I went there.
_____ 13. I find myself preoccupied with the future or the past.
_____ 14. I find myself doing things without paying attention.
_____ 15. I snack without being aware that I'm eating.

Scoring: To score the scale, simply compute a mean (average) of the 15 items.

Appendix J

State Difficulties in Emotional Regulation Scale (S-DERS).

DERS-18

Response categories:

1	2	3	4	5
Almost Never	Sometimes	About Half the Time	Most of the Time	Almost Always
(0-10%)	(11-35%)	(36-65%)	(66-90%)	(91-100%)

1. __________ I pay attention to how I feel.
2. __________ I have no idea how I am feeling.
3. __________ I have difficulty making sense out of my feelings.
4. __________ I am attentive to my feelings.
5. __________ I am confused about how I feel.
6. __________ When I'm upset, I acknowledge my emotions.
7. __________ When I'm upset, I become embarrassed for feeling that way.
8. __________ When I'm upset, I have difficulty getting work done.
9. __________ When I'm upset, I become out of control.
10. __________ When I'm upset, I believe that I will remain that way for a long time.
11. __________ When I'm upset, I believe that I'll end up feeling very depressed.
12. __________ When I'm upset, I have difficulty focusing on other things.
13. __________ When I'm upset, I feel ashamed with myself for feeling that way.
14. __________ When I'm upset, I feel guilty for feeling that way.
15. __________ When I'm upset, I have difficulty concentrating.
16. __________ When I'm upset, I have difficulty controlling my behaviors.
17. __________ When I'm upset, I believe that wallowing in it is all I can do.
18. __________ When I'm upset, I lose control over my behaviors.

Appendix K

Visual Analogue Scales (VAS)

ID Number: ______ Session: ______Time: pre / post

Please read each word carefully and draw a mark on each line indicating how you feel at THE PRESENT MOMENT:

1. **Alert**

   STRONGLY AGREE ____ STRONGLY DISAGREE

2. **Distracted**

   STRONGLY AGREE ____ STRONGLY DISAGREE

3. **Calm**

   STRONGLY AGREE ____ STRONGLY DISAGREE

4. **Stressed**

   STRONGLY AGREE ____ STRONGLY DISAGREE

5. **Accepting**

   STRONGLY AGREE ____ STRONGLY DISAGREE

6. **Aware**

   STRONGLY AGREE ____ STRONGLY DISAGREE

7. **Present-Focused**

   STRONGLY AGREE ____ STRONGLY DISAGREE

8. **Disinterested**

   STRONGLY AGREE ____ STRONGLY DISAGREE

9. **Fatigued**

   STRONGLY ____ STRONGLY

AGREE DISAGREE

10.Attentive

STRONGLY AGREE ____ STRONGLY DISAGREE

Appendix L

Ethics Approval Letter

UNIVERSITY of TASMANIA

07 June 2019

Dr Allison Matthews
C/- Psychology, UTAS

Sent via email

Dear Dr Matthews

REF NO: H0017994
TITLE: The Effects of Video Games and Mindfulness Meditation on Neural Correlates of Attention

Document	*Version*	*Date*
Human Research Ethics Application	v2	
Study Protocol	v2	13May2019
Participant Information Sheet and Consent Form	v2	15May2019
Muse End User License Agreement Terms of Service		
Pip End User License Agreement Terms of Service		

The Tasmania Health and Medical Human Research Ethics Committee (HREC) considered and approved the above documentation on **21 May 2019** to be conducted at the following site(s):

University of Tasmania

Please ensure that all investigators involved with this project have cited the approved versions of the documents listed within this letter and use only these versions in conducting this research project.

This approval constitutes ethical clearance by the Health and Medical HREC. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approvals of other bodies or authorities are required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

In accordance with the National Statement on Ethical Conduct in Human Research, it is the responsibility of institutions and researchers to be aware of both general and specific legal requirements, wherever relevant. If researchers are uncertain they should seek legal advice

Human Research Ethics Committee (Tasmania) Network
Research Ethics and Integrity Unit
Office of Research Services
Private Bag 1
Hobart Tasmania
7001
Australia
T +61 3 6226 6254
E human.ethics@utas.edu.au
ABN 30 764 374 782 /CRICOS 00586B
utas.edu.au

to confirm that their proposed research is in compliant with the relevant laws. University of Tasmania researchers may seek legal advice from Legal Services at the University.

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the *National Statement on the Ethical Conduct in Human Research* (NHMRC 2007 updated 2018).

Therefore, the Chief Investigator's responsibility is to ensure that:

(1) All investigators are aware of the terms of approval, and that the research is conducted in compliance with the HREC approved protocol or project description.

(2) Modifications to the protocol do not proceed until **approval** is obtained in writing from the HREC. This includes, but is not limited to, amendments that:

- (i) are proposed or undertaken in order to eliminate immediate risks to participants;
- (ii) may increase the risks to participants;
- (iii) significantly affect the conduct of the research; or
- (iv) involve changes to investigator involvement with the project.

Please note that all requests for changes to approved documents must include a version number and date when submitted for review by the HREC.

(3) Reports are provided to the HREC on the progress of the research and any safety reports or monitoring requirements as indicated in NHMRC guidance. The appropriate forms for reporting such events in relation to clinical and non-clinical trials and innovations can be located at the website below. All adverse events must be reported regardless of whether or not the event, in your opinion, is a direct effect of the therapeutic goods being tested. http://www.utas.edu.au/research-admin/research-integrity-and-ethics-unit-rieu/human-ethics/human-research-ethics-review-process/health-and-medical-hrec/managing-your-approved-project

(4) The HREC is informed as soon as possible of any new safety information, from other published or unpublished research, that may have an impact on the continued ethical acceptability of the research or that may indicate the need for modification of the project.

(5) All research participants must be provided with the current Participant Information Sheet and Consent Form, unless otherwise approved by the Committee.

(6) This study has approval for four years contingent upon annual review. A *Progress Report* is to be provided on the anniversary date of your approval. Your first report is due **21 May 2020,** and you will be sent a courtesy reminder closer to this due date. Ethical approval for this project will lapse if a Progress Report is not submitted in the time frame provided

(7) A *Final Report* and a copy of the published material, either in full or abstract, must be provided at the end of the project.

(8) The HREC is advised of any complaints received or ethical issues that arise during the course of the project.

UNIVERSITY of TASMANIA

(9) The HREC is advised promptly of the emergence of circumstances where a court, law enforcement agency or regulator seeks to compel the release of findings or results. Researchers must develop a strategy for addressing this and seek advice from the HREC.

Should you have any queries please do not hesitate to contact me on (03) 6226 6254 or via email Human.ethics@utas.edu.au.

Yours sincerely

Ailin Ding
Administration Officer

Human Research Ethics Committee (Tasmania) Network
Research Ethics and Integrity Unit
Office of Research Services
Private Bag 1
Hobart Tasmania
7001
Australia
T +61 3 6226 6254
E human.ethics@utas.edu.au
ABN 30 764 374 782 / CRICOS 00586B
utas.edu.au

Appendix M

Participant Information Sheet

1. I agree to take part in the research study named above.
2. I have read and understood the Information Sheet for this study.
3. The nature and possible effects of the study have been explained to me.
4. I understand that the study involves:
    - Completion of an online screening survey
    - Attending two experimental sessions (of approximately two hours each) one week apart, during which my brain activity will be recorded while I complete some computer-based tasks, involving pressing buttons in response to words/symbols on a screen.
    - Practicing video games, meditation or relaxation during the week in between the experimental sessions (approximately 20 mins per day for 5 days).
5. I understand that participation involves a slight risk of skin irritation if I have sensitive skin.
6. I have been provided with numbers which I can contact (see Information Sheet) if I have any concerns.
7. I understand that all research data will be securely stored on the University of Tasmania premises for 15 years from the publication of the results, and will then be securely destroyed.
8. Any of my questions have been answered to my satisfaction.
9. I understand that the researcher(s) will maintain confidentiality and that any information I supply to the researcher(s) will be used only for the purposes of the research.
10. I understand that the results of the study will be published as group data, and I will not be identified as a participant.
11. I understand that my participation is voluntary and that I may withdraw at any time without any effect and may request that my data be withdrawn from the research up until 31st August 2019.

Participant's name: ____

Participant's signature: __________________________________Date: ____________________

Statement by Investigator

☐ I have explained the project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation

Investigator's name: ____

Investigator’s signature: ____________________________Date: __________________________

Appendix N

Training Instructions for Intervention

Instructions – Mindfulness/Muse

1. Locate yourself in a quiet room where you won't be distracted.
2. Sit down on a comfortable chair or cushion with your back straight. You can sit with your legs crossed or out in front of you, and you can wrap a blanket around y and comfort if you wish.
3. Ensure the Muse headband is **fully charged** by tapping the power butto power level [look for 5 lights].
4. Open the **Muse app** on your phone
5. Login with your account.
6. Place the Muse headband over your ears and forehead.
7. On the 'Meditate' screen, ensure the following options are selected:
   a. **Length:** 10 or 20 minutes (depending on the day)
   b. **Soundscape:** Rainforest
   c. **Exercise:** Intro to Muse.
      i. **Note:** You can find 'Intro to Muse' within the **Muse Essentials** option. This study will progress through the **10** Muse Essentials courses.
      ii. See the **'Daily Task Schedule'** below for details on which course you should choose on which day and the duration.
8. **Calibration** will then begin. Listen to the instructions and adjust the headband as necessary.
9. Listen to the audio instructions. It is important that you listen to the entire instructions (although you don't need to listen to the instructions for every new session).
10. Click "Skip to results"
11. Click "Save".

Each day for 7 days, complete **the following sessions.**

<u>Daily Task Schedule:</u>

Day 1:

Intro to Muse (10 minutes)

Training a Puppy (10 minutes)

Day 2:

Sensation of Breath (10 minutes)

Counting Breaths (10 minutes)

Day 3:

Sitting Comfortably (10 minutes)

Finding your Soundscape (10 minutes)

Day 4:

Dealing with Distraction (20 minutes)

Day 5:

Working with Discomfort (20 minutes)

Day 6:

Lowering the Bar (20 minutes)

Day 7:

Bridging to Daily Life (20 minutes)

Trouble shooting

If you are having **issues connecting** your phone with the Muse headband:

- Make sure location is enabled on the phone or tablet
- If you are using/intend to use Apple AirPods, make sure those are connected before connecting the headband
- If 'Problems Connecting' appears, tap on the prompt and select the corresponding headband device.
- User guide for further troubleshooting is available at https://tinyurl.com/MuserGuide

---

If anything goes wrong (e.g. the app or device won't work, calibration won't work, etc.) or if you have any questions at all, please contact any of the following researchers

James Brady

Ph: 04

Email: james.brady@utas.edu.au

Bronte Matthews

Ph: 04

Email: brontem2@utas.edu.au

Safety Information

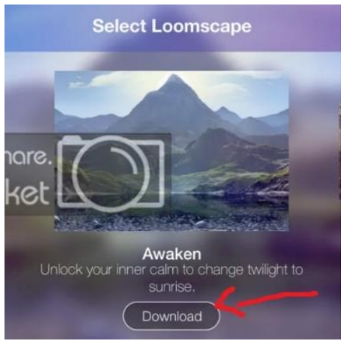
- In rare cases, people experience seizures or blackouts due to exposure to flashing lights and patterns created by the display of certain applications on mobile or other such similar devices.
- If you have done so, or have experienced any nausea, involuntary movements, tingling, numbness, or vision issues while using such devices in the past, you should consult with your doctor before using similar applications and should immediately cease all such use of such applications should the symptoms re-occur.
- In any event you should avoid prolonged use of such applications to minimize any possible discomfort or fatigue, including any muscle, joint or eye strain and should closely monitor your children's use of technology to avoid possible problems.

Hardware Safety

- Do not dispose of MUSE into fire or hot oven, or mechanically crush or cut the MUSE or the battery contained within, as this may result in an explosion.
- Do not expose the MUSE to an extremely high temperature environment, as this may result in an explosion or the leaking of flammable liquid or gas.
- Do not expose the MUSE to extremely low air pressure, as that may result in an explosion or the leakage of flammable liquid or gas.

Instructions – Relaxation/PIP

1. Locate yourself in a quiet room where you won't be distracted.
2. Sit down on a comfortable chair or cushion with your back straight. You can sit with your legs crossed or out in front of you, and you can wrap a blanket around you for warmth and comfort if you wish.
3. Ensure your mobile phone's **Bluetooth connectivity** option is enabled.
4. Ensure the Pip device is **fully charged.** Plug Pip into a USB outlet and ensure the red light is no longer on [fully charged]
5. Hold the Pip's sensor between your thumb and forefinger and let go, holding and releasing (each for 1 second at a time) until a green light flashes.
6. Open the '**Loom'** app on your mobile phone
7. Click 'settings' in the top right-hand corner of the home screen and change **session length** to '**Long'** and ensure **Music** is **'On'.**
8. Select '**New session'** in the Loom menu
9. **Install** the additional pictures **'Awaken'** and **'Enchanted forest'** in the Loomscape option menu (this will require WiFi or internet connection).
10. Check that phone's audio is turned on.
11. Begin relaxing!



____

Each day for 7 days, complete **the following sessions.** Your sessions should sum to approximately **20 minutes** per day. If the first session takes longer than 15 minutes, choose another short or medium session to complete so that you complete approximately 20mins. Similarly, if the two sessions take less than 20 minutes, choose another short or medium session to make the time up to approx. 20 minutes.

Daily Task Schedule:

Day 1:	New life (long session)

Awaken (long session)

Day 2:

Enchanted forest (long session)

New life (long session)

Day 3:

Awaken (long session)

Enchanted forest (long session)

Day 4:

New life (long session)

Awaken (long session)

Day 5:

Enchanted forest (long session)

New life (long session)

Day 6:

Awaken (long session)

Enchanted forest (long session)

Day 7:

Choose any two long sessions to complete

Trouble shooting

If you start a session, and after a few minutes there is no progress (i.e., no change in the visual scene or the progress bar at the bottom of the screen is not changing from blue to green), you could try stopping and restarting the session, or reconnecting or re-pairing the pip device (see below).

Re-connecting the device

Go to ‘Menu’, Click ‘devices’, click ‘disconnect’

Then click ‘reconnect’

Re-pairing the device

Go to ‘Menu’, Click ‘devices’, click ‘delete’ and then ok

Click ‘new pip’, and then ‘start

Follow the instructions: Grip the Pip’s sensor and let go, holding and releasing (each for 1 second at a time) until a green light flashes.

Click ‘connect to bluetooth’

Select ‘New Session’ in the Loom menu.

If anything goes wrong (e.g. the app or device won't work etc.) or if you have any questions at all, please contact any of the following researchers:

James Brady

Ph: 04

Email: james.brady@utas.edu.au

Bronte Matthews

Ph: 04

Email: brontem2@utas.edu.au

Safety Information

Battery

- Pip contains a lithium-polymer battery.
- Charge the battery only with the supplied micro USB charging cable. Do not attempt to remove the battery.
- The lithium-polymer battery might present a fire or chemical burn hazard or might explode if mistreated.
- Do not attempt to disassemble, crush, or puncture the battery.
- Do not heat the battery above 60 degrees Celcius.

Caution

- This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter.

Appendix O

Training Outcome Questionnaire

Training Outcome Questionnaire

Now that you have received instructions on the training task that you will complete over the next week, please answer the following questions:

	1 Not at all	2	3	4	5 Some what	6	7	8	9 Very much
Do you think this training is likely to improve your attention?									
Do you think this training is likely to improve your ability to complete the computer tasks?									
Do you think this training is likely to improve your emotional wellbeing?									